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AN EXPERIMENTAL EVALUATION OF THE CONTRIBUTION OF SEQUENCING, PRETESTING, AND ACTIVE STUDENT RESPONSE TO THE EFFECTIVENESS OF PROGRAMMED TV INSTRUCTION. STUDIES IN TELEVISED INSTRUCTION, REPORT 3.

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A SERIES OF EXPERIMENTS WAS CONDUCTED TO TEST THE EFFECTIVENESS OF TELEVISED INSTRUCTION. THIS STUDY, THE THIRD IN A SERIES, EXPLORED THE ROLE IN FIXED-PACE TELEVISION INSTRUCTION OF SOME OF THE TECHNIQUES AND PRACTICES EMPLOYED IN TEACHING-MACHINE INSTRUCTION. THREE SEPARATE EXPERIMENTS WERE CONDUCTED--(1) A JUNIOR HIGH SCHOOL LESSON ON NEWTON'S LAWS OF MOTION WAS USED TO EVALUATE THE EFFECTIVENESS OF ACTIVE STUDENT RESPONSE. THE RESULTS WERE INTERPRETED TO MEAN THAT MERELY REQUIRING ACTIVE RESPONSE IS NOT SUFFICIENT. TO BE EFFECTIVE, LESSONS MUST BE ADEQUATELY PREPARED TO ENABLE STUDENTS TO MAKE CORRECT RESPONSES. (2) THE EFFECTIVENESS OF A PROGRAMED OR SEQUENCE LESSON ON MOVIES REQUIRING ACTIVE RESPONSE WAS CONTRASTED WITH THE IDENTICAL LESSON WHICH DID NOT REQUIRE ACTIVE RESPONSE. STUDENTS WHO MADE ACTIVE RESPONSES RATED SIGNIFICANTLY HIGHER ON ACHIEVEMENT TESTS THAN DID THEIR COUNTERPARTS WHO ONLY PASSIVELY VIEWED AN IDENTICAL LESSON. (3) AN EVALUATION WAS MADE OF THE EFFECTIVENESS OF ADDING SEVERAL STAGES OF TRYOUT AND REVISION TO PROGRAMED LESSONS. A TRYOUT CONSISTED OF DETERMINING WHETHER STUDENTS COULD MAKE CORRECT RESPONSES AT EACH STEP OF A PROGRAMED LESSON. THE VALUE OF THIS PROCEDURE WAS ATTRIBUTED TO THE SUPERIOR CAPABILITY OF REVISED PROGRAMS TO ELICIT CORRECT RESPONSES. REVISION CONSISTED OF ALTERATION OF THE PROGRAM TO MAKE STUDENTS BETTER ABLE TO RESPOND CORRECTLY. RELATED REPORTS ARE ED 003 646 THROUGH ED 003 653.
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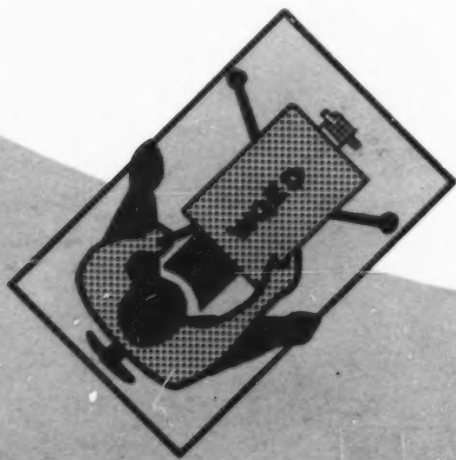
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STUDIES IN TELEVISED INSTRUCTION



THE CONTRIBUTION OF SEQUENCING, PRE-TESTING, AND ACTIVE STUDENT RESPONSE TO "PROGRAMMED" TV INSTRUCTION

3



PITTSBURGH, PENNSYLVANIA

STUDIES IN TELEVISED INSTRUCTION

Report Number 3

AN EXPERIMENTAL EVALUATION OF THE CONTRIBUTION OF SEQUENCING,
PRE-TESTING, AND ACTIVE STUDENT RESPONSE TO THE EFFECTIVENESS
OF "PROGRAMMED" TV INSTRUCTION -- Studies in
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Report 3.

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OVERVIEW

This is one of a series of reports on studies that use student responses to improve televised instruction. In these studies student response was used in three different ways. All three kinds of use shared the common objective of utilizing student responses to provide tangible, measurable indications of the adequacy of instructional procedures for attaining the educational goals of TV lessons.

• 1. USE OF STUDENT RESPONSE •

... To Pre-test a TV Lesson

Student responses on an achievement test following a preview showing of a TV lesson were used as a basis for preparing a revised version of the lesson. Student performance on each test question indicated which points were fairly well learned and which points were not. This information provided useful feedback to the TV instructor, guiding him in the preparation of a more effective revision of his lesson.

• 2. USE OF STUDENT RESPONSE •

... To Evaluate "Programming" Adequacy

... To Enhance Learning Effectiveness

"Programming" techniques derived from research on self-instructional devices were applied in the preparation of TV lessons. A primary purpose of these techniques was to facilitate correct responses by students. Procedures were designed to elicit active responding throughout the lesson. Students' ability to respond correctly provided evidence of how adequately the lesson sequences were programmed. Also, when students were encouraged to make frequent active responses to lessons programmed so they could respond correctly, the effectiveness of the lessons was significantly increased. Student responding was thus used first, to indicate the adequacy of lesson programming and second, to increase lesson effectiveness.

• 3. USE OF STUDENT RESPONSE •

... To Evaluate Incentive Created by a TV Lesson

A TV lesson was designed to stimulate student follow-up activity. Students were encouraged to perform experiments at home that they had seen demonstrated on TV. Student responses in performing experiments at home on their own indicated the effectiveness of the TV lesson in providing an incentive for follow-up activity.

Much of the responsibility for attaining the instructional objectives of a TV lesson rests with TV teachers and producers. Student responses can be considered as the building blocks of the program. This means devising instructional procedures that will elicit appropriate responses, and judging these procedures as adequate only when students do, in fact, respond appropriately. This kind of careful and systematic attention to student responses should contribute strongly to the successful attainment of educational objectives.

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The report presented in this volume illustrates the dual use of student responses: to test programming adequacy and to enhance learning effectiveness.

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ABSTRACT

The purpose of this study has been to explore the role in fixed-pace TV instruction of some of the techniques and practices employed in teaching-machine instruction. This has included an investigation of the effectiveness for learning of sequencing or programming lesson content, of requiring active student response, and of pre-testing sequenced or programmed TV lessons. Three separate experiments were conducted.

In one experiment, using a Junior High School science lesson on "Newton's Laws of Motion" an attempt was made to evaluate the effectiveness of requiring students to make active responses in the course of a conventional TV lecture. Achievement test results for students who watched this lesson and who were encouraged to make active responses were compared with those of students who watched the same lesson but who were not encouraged to make active responses. No significant differences in achievement were discovered. The results were interpreted to mean that merely requiring active response is not sufficient. To be effective, lessons must be adequately prepared to enable students to make correct responses.

In a second experiment, the effectiveness of a programmed or sequenced lesson on "Movies" requiring active response was contrasted with the identical lesson which did not require active response. Students who made active responses averaged significantly higher on achievement tests than did their counterparts who merely passively viewed an identical lesson. These findings suggest that although it is necessary to program lessons to enable students to make correct, active responses, it is beneficial for learning if students are stimulated to and, in fact, do respond actively.

The third and final experiment sought to evaluate the effectiveness of adding several stages of tryout and revision of "programmed" lessons. The tryout consisted of determining whether students could make correct responses at each step of a programmed lesson. Revision consisted of alteration of the program in order to make students better able to respond correctly. The version of a lesson on "Levers" which underwent the last stage of revision proved superior to its immediate predecessor. The value of this tryout and revision procedure is attributed to the superior capability of revised programs to elicit correct responses.

All three features of teaching-machine instruction, programming, pre-testing, and requiring active student response to programmed sequences, appear to contribute to effective fixed-pace TV instruction.

INTRODUCTION

In an earlier study in this series (3), evidence was reported on the feasibility and effectiveness for learning of encouraging students to make active responses during televised lessons on science. Achievement test results of students who watched a "programmed" lesson and who were encouraged to make active responses throughout the lesson were generally superior to the results of students who watched the same lesson presented as a conventional TV lecture. There were three key features cited as contributing to the effectiveness of the "programmed" lesson. These included: (a) the sequencing of lesson content to enable students to make correct responses at each step in the lesson; (b) the preliminary empirical tryout of the lesson to determine whether the sequencing was, in fact, adequate to elicit correct student responses; and (c) the encouragement of students to make active responses. In this report, "programmed" lessons mean those which comply with at least the first of these conditions.

"Programming" consists of the reduction of lesson content into small steps that students can master. By mastery is meant student ability to make correct responses. Each segment or step contains cues of sufficient strength to elicit correct student responses. The mastery of each step, in turn, becomes a cue of sufficient strength to enable the student to proceed to the next step and make another correct response. Thus, not only must careful seeding of cues be accomplished within a segment, but segments themselves must be carefully ordered or sequenced, for the mastery of any given step is contingent on the mastery of prior steps.

The over-all objective of programming is the assurance of a high probability of correct student response at each step (9). It has been suggested (12 & 13) that it is important to assure correct responding in order to avoid wasteful trial and error and the possible fixation of incorrect responses. To achieve that assurance, an integrated and systematic programming approach is used in teaching-machine instruction and research.

Individual elements of what is called "programming" have been investigated in instructional film research on student participation. During instructional

films, students have been stimulated to make active responses. The effectiveness of such participation procedures have been separately demonstrated for the following factors: guidance of student responses (8), reduction of lesson content into small steps or segments (10), and presentation of lesson material at relatively slow rates (1, 7, & 14). The superior learning results due to each of these variables has been attributed to their effect on the correctness of the elicited responses. Previous instructional film research and instructional television research has thus evaluated single features of the programming approach. It has not approximated the integrated programming approach employed in self-instruction with teaching machines.

The purpose of the present study is to apply the integrated programming approach to televised instruction. It is further to evaluate the specific contribution to the effectiveness of instruction of each of the following factors: (a) the programming or sequencing of learning materials; (b) the preliminary tryout of such sequences; and (c) the encouragement of active response followed by reinforcement.

There is evidence from research on individual instruction with teaching machines bearing on the role of these factors. Studies have shown the importance of trying out a program and evaluating its effectiveness in eliciting correct student responses (6, 11, & 12). In another study, the superiority of a logical sequence of steps over a random arrangement of steps was demonstrated (2). ~~The sequence of steps over a random arrangement of steps was demonstrated (2).~~ The need for careful and systematic preparation of programs was investigated and confirmed in still another study (5).

The present study seeks to investigate these factors shown to be effective in individual instruction in the context of televised instruction for groups of students.

METHOD

Three separate experiments were performed. In order to evaluate the contribution to the effectiveness of programmed TV instruction that sequencing, pre-testing, and active student response make, each one of the three experiments was designed to evaluate the contribution of only one of these three variables. In one experiment, the effectiveness of a nonprogrammed, conventional lesson requiring active student response was compared with that of its counterpart which was identical except that it did not require students to make active responses. In a second experiment, the effectiveness of a programmed lesson requiring active response was compared with that of a lesson which was identical but which did not require active response. In a third experiment, the effectiveness of a programmed lesson which had undergone an additional stage of tryout and revision was compared with that of its immediate predecessor.

The following procedures were adhered to in all three experiments. A competent Junior High School science teacher prepared a comprehensive statement of lesson objectives including facts students were expected to acquire and concepts they were expected to understand. The identical statement of objectives was used both as a basis for preparing the lessons to be shown on the air and also as a basis for developing achievement tests to be administered following the telecast of the lesson. All lessons were part of a science series telecast for seventh and eighth graders throughout the entire school year.

On the day each of the three lessons was scheduled to be telecast, the experimental version was telecast on one channel and the control was simultaneously telecast on a second channel. Channels 13 (VHF) and 16 (UHF) of Metropolitan Pittsburgh Educational Television Stations (WQED-WQEX) were used in the simultaneous telecast.

Students in each class scheduled to participate in an experiment were paired off in advance on the basis of sex and intelligence, and one member of each pair was randomly assigned to one of two rooms. The group in one room watched the experimental version; the other group, in a different room, watched the control version. The random assignment of the members of pairs of students from each class to experimental or control groups meant that the performance of individuals rather than intact classes provided the units for observation.

Identical achievement tests¹ were administered to both experimental and control groups (see Appendix B). One test, a test of acquisition, was administered either immediately following the telecast or the next day (at the administrative convenience of the schools). A second test, a test of retention, was administered approximately two weeks later.

The three experiments differed from one another in the following ways:

1. Lesson on "Newton's Laws of Motion"

The purpose of this experiment was to determine whether merely requiring students to make active response without systematically preparing them to be able to make correct responses would increase learning efficiency. Accordingly, a conventional, nonprogrammed lesson on "Newton's Laws of Motion" was presented to both the experimental and control groups. In the experimental version, however, provision was made throughout the lesson for active student response. The lecturer paused at selected places in the lesson and at the same time, question marks were flashed on the screen to encourage students to complete statements he had begun. Students were instructed to say the answer to themselves. Also, at various review points they were instructed to fill in blanks on active response workforms. In the preparation of the lesson, there was no preliminary tryout to determine whether students could, in fact, make correct responses. (The script for this experiment appears in Appendix A.) The identical script was used in the control version of the lesson except that no opportunity was provided for active student responding. Students in the control group merely watched and listened to the lesson.

Four classes from four different schools with a total of 150 students participated in this experiment. As noted above, students within each of the four classes were randomly assigned to experimental or control groups.

2. Lesson on "How Movies Work"

The purpose of this experiment was to test the hypothesis that a "programmed" lesson (a lesson that has been sequenced and pre-tested) that requires active student

¹Pre-tests had been administered to sample classes before lessons were shown on the air. This served two purposes: (a) to provide a measure of the amount of prior knowledge students had; and (b) to aid in the preparation of the achievement test to be used in the experiment proper.

response will be more effective than the same "programmed" lesson which students merely listen to and watch and which does not require them to make active responses. To test this hypothesis, an identical, sequenced and pre-tested lesson was presented to both experimental and control groups. (The script for this lesson appears in Appendix A.) However, in the experimental version only was provision made for active student response. Lecturer pauses and question marks flashed on the screen were intended to elicit active responding. Instructions to students called for them to say the answers to themselves. In the course of the lesson presentation, the lecturer, after a pause to allow student response, supplied the missing word or words. In the control version, students merely listened to the same sequenced and pre-tested material. There were no pauses and no opportunities to complete statements. Students were thus not encouraged to make active responses.

The total sample consisted of three classes of 156 seventh and eighth grade students from three different schools. Students within each of the three classes were randomly assigned to experimental or control groups.

3. Lesson on "Levers"

The purpose of this experiment was to demonstrate the increase in effectiveness in programmed lessons that can be brought about by providing additional stages of tryout. To determine the contribution of additional pre-testing, a lesson on "Levers" was sequenced. It was then tried out with a group of three students. The lesson was verbally presented without benefit of a number of demonstrations and other visual aids. A record was kept of student responses at each step in the lesson.

A revised version of the lesson was prepared based on the results of the first tryout. Portions of the lesson in which students had made incorrect responses were changed. The revised version was, in turn, tried out with another group of three students. It, too, was then revised based on the results showing whether students were able to make correct responses.

Three versions of the lesson had been prepared: the original, the first revision, and the second revision. The latter two versions were the ones compared in this experiment.

The experimental (second revision) and control (first revision) versions of the lesson on levers were shown to 186 students in four different classes. Here again, students within each of the four classes were randomly assigned to experimental or control groups.

RESULTS

Achievement test data were analyzed to compare the relative effectiveness of the experimental and control versions of lessons in each of the three separate experiments.

1. Lesson on "Newton's Laws of Motion"

(Active Response vs Passive Viewing During Nonprogrammed Lesson)

Data were obtained from two forms of an achievement test administered at two different times. One test, a test of acquisition, was administered the day after the telecast; the second, a test of retention, was administered approximately two weeks later. The maximum number of points possible on either Form A or Form B of the test was 48.

The experimental group of students who made active responses during a non-programmed, conventional lesson received achievement test scores that were not significantly higher than those of students in the control group. The latter group had watched the identical, nonprogrammed lesson but had made no active responses. No significant differences between experimental and control groups were found on either form of test administered the next day or two weeks later. Tables 1, 2, 3, and 4 summarize the analysis of variance² for all four tests.

²Correction was made for unequal cell frequencies.

Table 1
Analysis of Variance for Form A of Test
Administered the Day After the Telecast
(Lesson on Newton's Laws)

	<u>Mean Square</u>	<u>D.F.</u>	<u>F</u>	<u>P</u>
Methods	13.28	1	.24	—
IQ	47.69	1	.85	—
Schools	167.67	3	3.00	.05*
Methods x IQ	63.41	1	1.13	—
Methods x Schools	36.05	3	.64	—
IQ x Schools	117.10	3	2.09	—
Methods x IQ x Schools	13.67	3	.24	—
Within	55.9	60	—	—

	<u>Mean Achievement Scores</u>	<u>S.D.</u>
Experimental Group	12.5	5.4
Control Group	11.5	3.8

*significance at the 5 percent level

Table 2
Analysis of Variance for Form B of Test
Administered the Day After the Telecast
(Lesson on Newton's Laws)

	<u>Mean Square</u>	<u>D.F.</u>	<u>F</u>	<u>P</u>
Methods	8.59	1	.20	—
IQ	519.82	1	12.38	.001***
Schools	158.81	3	3.78	.05*
Methods x IQ	27.10	1	.64	—
Methods x Schools	7.70	3	.18	—
IQ x Schools	2.23	3	.05	—
Methods x IQ x Schools	110.09	3	2.62	—
Within	42.0	58	—	—

	<u>Mean Achievement Scores</u>	<u>S.D.</u>
Experimental Group	11.8	4.6
Control Group	11.1	5.9

*significance at the 5 percent level

***significance at the .1 percent level

Table 3
Analysis of Variance for Form A of Test
Administered Two Weeks After the Telecast
(Lesson on Newton's Laws)

	<u>Mean Square</u>	<u>D.F.</u>	<u>F</u>	<u>P</u>
Methods	0.0	1	0	—
IQ	163.8	1	4.04	—
Schools	164.4	2	4.06	.05*
Methods x IQ	125.04	1	3.09	—
Methods x Schools	29.90	2	.74	—
IQ x Schools	113.62	2	2.80	—
Methods x IQ x Schools	5.89	2	.14	—
Within	40.5	28	—	—

	<u>Mean Achievement Scores</u>	<u>S.D.</u>
Experimental Group	12.2	5.4
Control Group	12.2	6.9

*significance at the 5 percent level

Table 4
Analysis of Variance for Form B of Test
Administered Two Weeks After the Telecast
(Lesson on Newton's Laws)

	<u>Mean Square</u>	<u>D.F.</u>	<u>F</u>	<u>P</u>
Methods	.24	1	.06	—
IQ	6.17	1	.16	—
Schools	41.49	2	1.05	—
Methods x IQ	19.21	1	.49	—
Methods x Schools	1.47	2	.04	—
IQ x Schools	53.85	2	1.36	—
Methods x IQ x Schools	6.97	2	.18	—
Within	39.5	34	—	—

	<u>Mean Achievement Scores</u>	<u>S.D.</u>
Experimental Group	9.2	2.6
Control Group	9.0	3.5

In this experiment, active response to a nonprogrammed, conventional lesson did not prove superior to passive viewing of the same lesson. The nonsignificant differences between experimental and control groups suggest that there is little basis for believing that merely requiring or encouraging students to make active responses, without employing methods to insure that they will be capable of making correct responses, will add to the effectiveness of instruction.

2. Lesson on "How Movies Work"

(Active Response vs Passive Viewing During Programmed Lesson)

Learning was more efficient for students who made active responses during the programmed lesson on "Movies" than it was for students who merely listened to and watched an identical, programmed version of the lesson. On both a test of acquisition and of retention, the experimental group (active response group) averaged higher on an achievement test than did the control group (passive viewing). On a 61-point test of acquisition, the experimental group had an average score of 23.7; the control group, an average score of 21.0. This difference is statistically significant. Table 5 summarizes the analysis of variance for this test.

Table 5
Analysis of Variance for Test
Administered the Day After the Telecast
(Lesson on Movies)

	Mean Square	D.F.	F	P
Methods	290.9	1	6.28	.05*
IQ	1422.1	1	30.71	.001***
Grade Level	.8	1	.02	—
Methods x IQ	8.7	1	.19	—
Methods x Grade Level	10.4	1	.22	—
IQ x Grade Level	58.6	1	1.26	—
Methods x IQ x Grade Level	7.0	1	.15	—
Within	46.3	148	—	—

	Mean Achievement Scores	S.D.
Experimental Group	23.7	3.4
Control Group	21.0	4.2

*significance at the 5 percent level

***significance at the .1 percent level

On a 74-point test of retention, the experimental group had an average score of 24.5; the control group, an average score of 20.5. The difference between the test performance of experimental and control groups is statistically significant. The results of the analysis of variance are summarized in Table 6.

Table 6
Analysis of Variance for Test
Administered Two Weeks After the Telecast
(Lesson on Movies)

	<u>Mean Square</u>	<u>D.F.</u>	<u>F</u>	<u>P</u>
Methods	592.0	1	7.78	.01**
IQ	3124.3	1	41.06	.001***
Grade Level	.7	1	.01	—
Methods x IQ	2.2	1	.03	—
Methods x Grade Level	4.2	1	.06	—
IQ x Grade Level	191.8	1	2.52	—
Methods x IQ x Grade Level	21.4	1	.28	—
Within	76.1	140	—	—

	<u>Mean Achievement Scores</u>	<u>S.D.</u>
Experimental Group	24.5	5.7
Control Group	20.5	5.9

**significance at the 1 percent level
***significance at the .1 percent level

The results on the immediate and delayed tests both suggest that active response makes a contribution to learning efficiency over and above the contribution made by the "programming" of lesson content. It would seem that it is not simply enough for a lesson to be programmed and hence capable of eliciting correct responses. It appears to be important for learning effectiveness that students actually make responses to the programmed lesson.

3. Lesson on "Levers" (First Revision vs Second Revision of Programmed Lesson)

The results of the experiment using the lesson on "Levers" suggest that cumulative stages of tryout can produce additional gains in achievement test results.

On a 35-point test of acquisition, the experimental group which watched the last revised version of a lesson, scored 1.2 points higher than the control group which watched the next-to-last revised version. A t-test of the differences between these groups matched for ability was significant at the two percent level. Table 7 summarizes these results.

Table 7
t-test of Differences on a Test
Administered the Day After the Telecast
(Lesson on Levers)

	Mean Achievement Scores	S.D.	Difference Between Means	t	D.F.	P
Experimental Group	13.3	6.1				
Control Group	12.1	5.6				
			1.2	2.3	101	.02 ⁺

⁺significance between the 5 and 1 percent level

On the identical test used as a measure of retention, no significant differences were found. Table 8 summarizes these results.

Table 8
t-test of Differences on a Test
Administered Two Weeks After the Telecast
(Lesson on Levers)

	Mean Achievement Scores	S.D.	Difference Between Means	t	D.F.	P
Experimental Group	14.0	6.4				
Control Group	13.6	5.9				
			.4	.6	92	.50

The study in Report No. 1 (3) showed the efficacy of a first stage of revision of a conventional lesson. In interpreting the results in this study, it should be remembered that it was the last two stages of revision that were compared. Here, programmed lessons were revised. With each additional stage of revision of a programmed lesson, the number of errors students make in response to the lesson are likely to be reduced even further. However, large differences between two

different late stages of revision are, it would appear, not very probable. Nevertheless, in the test of acquisition, a significant difference in favor of the last revision was found. This finding suggests the utility of repeated pre-testing and revision of programmed, fixed-pace TV lessons.

DISCUSSION

A programmed lesson, and especially a programmed lesson which is given an empirical tryout to determine how well it will elicit correct student responses and which actually elicits correct student responses, enables students to attain higher levels of achievement. However, the lesson programmed for group instruction, it must be pointed out, is not as likely to be as successful in this objective as is the lesson programmed for individual instruction. Control over student response in group instruction is apt to be less secure and less accurate. But active student response can, nevertheless, be stimulated and it can contribute to the effectiveness of learning in group situations.

The findings on active response during group instruction that are reported in this study are consistent with the findings based on research on individual instruction. The findings are interpreted to mean that active responses must be correct ones, and that to enable students to make correct responses, special preparation of lesson content is required. It appears that active responses during a lesson not specially prepared to insure that responses will be correct may not make a contribution to efficient learning. The special preparation employed in this study to elicit correct responses consisted of "programming" of lesson content. Techniques of programming were similar to those used in individual teaching-machine instruction.

It is suggested that, for optimal results, it is not sufficient merely to program (that is, to sequence and pre-test) a lesson. In this experiment, encouraging students actually to construct or make responses to a "programmed" lesson led to higher achievement than was obtained by merely allowing students passively to listen to or watch the same "programmed" lesson. Thus, it is not the special preparation or programming alone which makes for superior student achievement. Active responses also appear to be essential.

The empirical tryout of a "programmed" lesson also appears to make a contribution to the effectiveness of learning. It accomplishes this through the effect it has on the probability that students can make correct responses at each step in a "program." The purpose of the tryout is to change lesson content which fails to elicit correct responses. A second stage of tryout will further improve the

lesson by reducing the likelihood that students will commit errors at any step in the program.

Teaching-machine "programs" divide lesson content into units called "frames." A frame is a physical unit, so much lesson content presented to the student at one time. Within a frame there are cues which, if properly selected, elicit a relevant, correct response. Experience with prior frames provide memory cues which can also elicit correct responses. The purpose of the preliminary tryout of frames is to evaluate cueing adequacy and to make revisions that will minimize the errors that students make. By trying out the program, the programmer attempts to increase the probability that a student will make the correct response in a given frame.

In TV instruction, whether of the conventional or "programmed" variety, the verbal presentation is largely oral and proceeds at a fixed rate of presentation. Once the instructor has spoken, his words are available to the student only in the form of memory cues. If the lesson is "programmed" and requires students to make active responses, it is in large measure memory cues which carry the burden of eliciting the appropriate responses in a given frame. If these cues are at first incapable of eliciting an appropriate response, the student no longer has the programmed stimulus materials directly available to him, as would be the case in a teaching machine visually presenting printed materials. Nor is he permitted to take his time, since the lesson proceeds at a fixed pace. The constraints imposed on student ability to respond by oral presentations, proceeding at a fixed pace, make preliminary tryout of a program perhaps even more urgent than it is in the case of self-instructional programs. Tryouts would appear to be best carried out under the conditions of fixed pacing that will prevail in the instructional situation.

It was suggested in an earlier report, Report No. 2 (4), that it is difficult to prepare "programs" suitable for instructing groups of students of widely varying ability. Efforts at creating groups as nearly homogeneous as possible is a reasonable solution to this problem. The tryout of the "programmed" TV lesson with such groups may lead to acceptable levels of student preparation to make correct active responses. Successive stages of tryout should prove even more effective in this respect.

Future research should be directed at determining the degree of group homogeneity in ability necessary before group instruction can begin approaching levels of achievement possible with individual instruction. Further research on the parameters of "programming" for groups receiving fixed-pace instruction will also be necessary. Successful efforts in this direction will be helpful in solving the logistical problems of providing quality instruction to the growing number of children in the student population.

Television, at present, has the capability of reaching large numbers of students at the same time. On the basis of results presented in this report, it also appears to have the capability of presenting programmed instruction which provides for the systematic control over student learning behavior. Such control is considered necessary for efficient and effective learning. The future efforts at devising ways of accommodating individual differences in student ability should make programmed TV instruction even more efficient and effective.

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APPENDIX A

Lecture Materials

1. Script on "Newton's Laws"
 - a. experimental and control lessons pp. A- 2 - A- 6
 - b. classroom "active response" worksheets pp. A- 7 - A- 9
2. Script on "Movies"
 - a. experimental and control lessons pp. A-10 - A-14
3. Script on "Levers"
 - a. experimental lesson pp. A-15 - A-18
 - b. control lesson pp. A-19 - A-22

Today we're going to talk about laws of motion. Because this topic is a very important one, we're going to have a slightly different kind of presentation, and I'd like you to pay particularly close attention.

At various times in the lesson, I'll review a few key points by flashing them on the screen. The sentences will have blank spaces. The sentences are the same as those on the forms you've been given. When I show them on the screen, see if you can fill in the blanks with the correct answer before I tell you what it is. Also, sometimes while I'm talking I will pause a moment before I say a key word. I'll flash a question mark on the screen when I'd like you to think of the key word. See if you can think of it before I say it. Doing this will help you to learn the lesson better.

Let's talk about the laws of motion. In the seventeenth century a great English scientist and mathematician, Newton, was interested in studying the movement of heavenly bodies. His observations of objects in motion here on the earth led him to formulate his three laws of motion that are today among the most important laws of physics.

The first law of motion is called the Law of Inertia. The second law of motion is called the Law of Acceleration. The third law of motion is called the Law of Action and Reaction.

It was difficult to discover these laws before people had a clearer idea of such things as force, mass, acceleration, friction, and gravity.

So before we attempt to see what Newton's Laws mean, let's make sure we know the meanings of a few words. First, I've mentioned that these laws relate forces to motion. What about the word motion? Know what it means? Does this book have motion? No! How about now when I pick it up and put it here. Was there motion? Yes. Why? Motion means a change of place or position. The book changed position so there was motion.

In everyday talk we often use the word force. What does force mean? Look: I can push the book over the table, or I can pull the book over the table. Force means only one thing. It's always a push or a pull.

Let's consider this word force for a moment. Do you think there are different kinds of forces? Do you think there are forces that make things go and forces that make things stop? There are, you know! There are forces that push on things. How about a ball rolling into bowling pins, or how about a skidding car on ice that hits another car. It pushes it, doesn't it? There are many examples you can name where a moving object pushes against anything it hits and exerts a force on it.

How about this kind of force. I can lift up a book, let it go, and it falls. Something pulled that book down. Of course, gravity. Gravity is a pulling force and not a pushing force. All of you have seen the force of gravity whenever you drop anything. Gravity pulls the objects to the ground. Here's another example of a pulling force. Whirl a stone on a string. The stone is pulling on the string. This is a pulling force.

So now you have seen examples of pulling forces and pushing forces. These forces made something move -- or made something move faster. In addition to moving objects, forces can also slow an object down and even stop it. How about this? Give the book a push -- it moves but then it stops. The force you know as friction stopped the book. Friction is also a force.

Now with some of the meanings of words like force, motion, friction, and gravity, we can explore a bit and see something of Newton's Laws of motion. Recall they explain Why things move and also relate forces to ?/ motion.

Let's start with this book on the table. You wouldn't expect that book to fall off the table, would you? If you went away for a while and came back, wouldn't you expect the book to still be there? Of course. The book remains still unless we push or pull it.

But did you know this? Anything that is moving will keep right on moving until something stops it. Look at this ball -- I can start it rolling and it wants to keep right on rolling but something stops it. A force, or forces, are acting on the ball. In this case perhaps gravity, air-friction, or collision with something on the table. The ball wanted to keep moving -- and it would have if friction or some other force hadn't acted on it to stop it. There is a name for what you have just seen. Inertia. Inertia means the tendency of objects like the ball, for example, to remain still if it's not moving, or the tendency of an object to keep on moving if it is moving. Let me show you inertia in a couple of other ways. Here's a card with a coin on it. Both are sitting on a water glass. Inertia is at work. Things that are still or at rest will remain that way. But what will happen if I apply a force to the card? Hit it with my finger? Will the coin go with the card? Watch! The coin fell into the glass. When a force acted on the card, the card moved -- why didn't the coin move in the same direction as the card? The coin wasn't attached to the card and therefore the force acting on the card which moved it away from the glass didn't act on the coin. The coin didn't move in the same direction that the card moved.

But why didn't the coin move away from the glass the way the card did? Inertia was at work. The coin was at rest and since no force acted on it either pushing it or pulling it in the direction the card went -- it didn't go in the same direction.

The reason it fell into the glass was that the card was no longer there to support it and gravity pulled it down. Inertia prevented the coin from travelling in the same direction as the card. The tendency of objects like the coin to remain still if it's not moving is called ?/ inertia. The tendency of an object like a rolling ball to keep on moving if it's moving is also called ?/ inertia.

The principle of inertia is the first of the laws of ?/ motion. This First Law of Motion says that an object at rest stays at rest, and an object moving keeps moving in the direction it started with a uniform or constant speed unless a force acts on the object. If a force acts on an object at rest it will now move. If a force acts on a moving object it can change its speed or change the direction it was going in. Let's try another simple thing to see this first law at work, and also try to reword the law. How about throwing this ball? It is at rest now. It will stay that way until I pick it up and begin to throw it. We start the ball moving rapidly as we move our arm. Then -- let it go. The ball keeps moving in the direction our hand was moving. It will keep moving to perhaps another person until other forces work on the ball. Let's try to say now in a couple of statements what has happened here and really see what Newton's first law means.

It requires a force to change the motion of an object -- either to start it or stop it, or to speed it up or to slow it down, or to change its direction.

Point #1: To change the motion of an object requires a ?/ f _ _ _ _ . (force)

This ball would have remained still if I hadn't picked it up. If no force acts on an object at rest it stays at rest.

Point #2: Unless a force acts on an object at rest it will stay at ?/ _ _ _ _ . (rest)

This ball would have kept moving in a straight line at the speed I threw it if gravity wasn't at work and there was air friction operating. If no force acts on an object in motion it keeps on moving at a uniform rate in a straight line.

Point #3: Unless a force acts on an object in motion, it keeps moving in a straight ?/ 1 _ _ _ _ . (line)

So much for Newton's first law. Let's explore his second law. Let's consider this first. Suppose you were watching a tug of war. Each team has three boys. All the boys are as strong as each other and that means each team is pulling as hard as the other. The force in one direction balanced out the force in the other direction. There is no motion in either direction because the forces are ?/ balanced. Now suppose that one team gets another boy. Now the team on the right is stronger. It can pull with 400 lbs. and the other team can only pull with 300 lbs. There is an unbalanced force of 100 lbs. in favor of the team on the right. Therefore, both teams will move to the right.

Newton's second law tells us that a force acting on an object causes acceleration. Acceleration is a change in motion, either going faster or slowing down.

Now we have to find out what relationship there is between unbalanced forces (like an extra man on a team playing tug of war) and the acceleration or change of motion that is produced. Let me try to show you Newton's second law or the relationship between unbalanced forces and changes of motion. Here is a cart. It is sitting still and will remain so until some force acts on it. If a string is attached to the cart and a force put on the string it will begin to move. Be accelerated. Watch what happens when I put a small force - a weight which pulls - on this string. There is acceleration. A change in ?/ motion. What if I put twice as much force here - twice as much weight? Acceleration will be twice as much. How about the size or mass of the cart? Does this have any effect upon the acceleration? Let's see. Let's put some weights in the cart and increase its mass. Recall this force (weight) made the cart move when empty. Let's apply the same force on the cart which is heavier now. Does it move? No! The greater the mass the more force is needed to cause a change in motion. Did you also notice which way the cart moved when it moved? It went in the same direction of the force that caused the motion.

Remember then Newton's second law of motion tells us that forces produce acceleration.

Point #4: Forces produce a change in motion or ?/ a c _ _ _ _ _ . (acceleration)

From our demonstration we say that: large forces produce large acceleration. No force - no acceleration, small force - small acceleration.

Point #5: Small forces produce ?/ _ _ _ _ _ accelerations. (small)

Point #6: If there is no force there will be no change in ?/ m _ _ _ _ _ . (motion)

You have seen, too, that the less mass of an object the more acceleration you can get using exactly the same force. Keep in mind too that acceleration always takes place in the same direction as the force that's causing it. All these ideas are included in Newton's second law of motion.

Now let's stop a moment and make sure you know what acceleration is. Recall now it is a change in velocity. Something that is moving like this - a ball rolling along a flat or level table - is not an example of acceleration. Acceleration means a speeding up or slowing down. The ball rolling along the level table kept going at a uniform rate. There was no speeding up or slowing down.

Here is an example of acceleration. Rolling a ball down a slope. The force of gravity made the ball move faster and faster. There was a change in rate of motion. Speeding up is an example of accelerated motion. Gravity was the force that made it speed up or accelerate. What about this? Slide a block of wood across a table. This did slow down. Really a change in motion. This too is an example of acceleration. Slowing down, you recall, as well as speeding up is acceleration. Friction was the force at work here to cause a decrease in velocity.

And now briefly let's see something of Newton's third law of motion. Something called Action and Reaction. Perhaps we can use this as an example. A gun. Many of you have fired a rifle. Ever notice how the gun "kicks" or hits your shoulder when it is fired? The explosion of the powder in a bullet pushes the bullet and also the gun. The bullet is pushed forward and the gun is pushed backward. But the gun doesn't move as fast nor as far as the bullet. This is because the gun has such a big mass. The gun weighs more than the bullet. Therefore the gun which weighs more got a smaller acceleration than the bullet which weighed less.

Newton's third law says for every action or (force) there is an equal and opposite reaction or (force). In the case of the gun firing, the explosion put a force on the bullet; that was the action. The bullet pushing on the gun was the reaction - an equal and opposite force.

Jets and rockets work on this principle of action and reaction. The engine has explosions in it. The engine pushes out the exhaust gases with a large force. This is the action. The exhaust gases push back on the engine with an equal and opposite reaction. This reaction makes the plane move.

Here perhaps is a way to help you think of Newton's third law of motion. We can take two spring balances and hook them together. Now I'm going to cause an action on one spring scale. I'm going to pull on it. If the law is true then there should be an equal and opposite reaction against the 2nd scale. If I pull with a force of 10 lbs. on one scale notice the scale reading on the other. It too reads ten pounds. There is an equal and opposite reaction for every action. You can probably think of many, many examples of action and reaction. How about walking, or leaning against a wall? When you lean against a wall does the wall also push against you? Let's review some key points about action and reaction.

Point #7: A bullet leaving the gun is an example of a _____. (action)

Point #8: The kick of the gun is an example of r e _____. (reaction)

Point #9: There is an equal and opposite reaction for every a _____. (action)

Let's summarize now. All forces are either pushes or pulls. Newton's first law says that every object tends to stay at rest or in motion unless a force acts on it. The tendency of a body not to change its motion is called inertia. Newton's second law says that a force causes a change in speed called acceleration. Acceleration depends upon the acting force. The third law says that there is an equal and opposite reaction to every action. This is demonstrated by the "kick" of a gun or jet planes or rockets.

Point #10: The tendency of an object not to change its motion is called i n _____.

Point #11: Changes in motion are called a c _____ s.

Point #12: The amount of acceleration depends on the amount of f _____ applied.

Point #13: There is an equal and opposite r _____ for every a _____.

WQED

Junior High School Science

Lesson on: Newton's Laws of Motion

Name _____

Grade _____
7th or 8th

School _____

Instructions: Fill in the information at the top of the page.

1. Today's science lesson on Newton's Laws will be given by Mr. Chemas.
2. Throughout the lesson Mr. Chemas will pause to let you think of words we'd like you to learn. A question mark will appear on the screen when he wants you to think of the word. See if you can think of the correct words before Mr. Chemas tells you what they are.
3. Sometimes Mr. Chemas will also stop to review some key points. He will show you some sentences on the screen which have some blanks in them. The same sentences are in the booklet I just gave you and there are blanks in the booklets too. Each blank means that a word is missing. If one word is missing, there will be one blank. If two words are missing, there will be two blanks.
4. Mr. Chemas will review each key point in the lesson and give it a number. We would like you to write in the correct missing word in your booklets alongside the point number he mentions. There is a blank space for each letter in the word.
5. For example:

If Mr. Chemas were to show this key sentence on the screen
and say:

Point number 1: Steam results when we b _ _ _ _ _ .

You would write in the correct words in the spaces alongside point number one in your booklets. Write in the correct words. (Pause) If you wrote "boil water" you're correct.

6. After Mr. Chemas tells you the correct answer, look back at the television screen and wait for the next key point. If your answer is not correct, don't bother to correct it. You might miss the next point.
7. Remember, sometimes Mr. Chemas will show you a question mark and pause to let you think the correct word! When he wants you to write the correct word in your booklets he will say -- Point number one - or point number two and so on.
8. Don't open your booklets until Mr. Chemas tells you to write in the correct words.
9. Don't take any other notes during the lesson. We will give you some notes later on.

Point
Number

1. To change the motion
of an object
requires a f _ _ _ _
2. Unless a force acts on
an object at rest
it will stay at _ _ _ _
3. Unless a force acts on
an object in motion,
it keeps moving
in a straight l _ _ _ _

NOW WATCH THE TV SCREEN

4. Forces produce a change
in motion or a c _ _ _ _ _
5. Small forces
produce _ _ _ _ _ accelerations
6. If there is no force
there will be
no change in m _ _ _ _ _

NOW WATCH THE TV SCREEN

Point
Number

7. A bullet leaving the gun
is an example of a _ _ _ _ _
8. The kick of the gun
is an example of r e _ _ _ _ _
9. There is an equal
and opposite reaction
for every a _ _ _ _ _

NOW WATCH THE TV SCREEN

10. The tendency of an object
not to change its motion
is called i n _ _ _ _ _
11. Changes in motion
are called a c _ _ _ _ _
12. The amount of acceleration
depends on the
amount of f _ _ _ _ _
13. There is an equal
and opposite r _ _ _ _ _
for every a _ _ _ _ _

MOVIES

Script for Experimental and Control Lessons

Today we're going to talk about how we see movement in moving pictures. This is a topic you have probably wondered about and we're going to try to make it easy for you to understand how we see movement in movies.

During the lesson I'm going to pose some questions and pause every now and then and let you think the right answers. I'll flash a question mark on the screen when you're supposed to think the correct answer. See if you can think the correct answer before I tell you what it is.

Watch this. There is a bird on one side of this card and an empty cage on the other. When I turn the card very slowly, like this, you see either the bird or the ?/ empty cage. When I twirl the card very quickly like this, you see the bird in the ?/ cage. In order to see the bird in the cage, the card must be turned over very ?/ quickly. When you look at the empty cage, an image is formed on the retina in the eye.

When you look at any object, an image is formed on the retina. Thus when I turn this card over and show you the bird, an image of the bird is also formed on the ?/ retina.

As you look at the bird, an image is formed on the retina which transmits a message about the bird to the brain. The retina transmits messages about all images that are formed on it to the ?/ brain. When I put the picture of the bird away, the image disappears from the retina of your eye, and the retina no longer sends messages to the ?/ brain. But images don't disappear from the retina instantaneously. They last for about 1/10 of a second after objects are taken away. It takes 1/10 of a second for the image to fade away. When I take the picture of the bird away, an image lasts on your retina for 1/10 of a ?/ second. During that 1/10 of a second the brain continues to receive a message about (about what on the retina) ?/ about the image on the retina. This is called persistence of vision. Persistence of vision means that after the picture is put away the brain continues to receive a message about the image on the retina for 1/10 of a (how long) ?/ second. At the end of 1/10 of a second the image on the retina fades away and the brain no longer receives a ?/ message.

When I twirl the card slowly, the retina first transmits a message to the brain about the bird. If I twirl the card around, the message to the brain about the bird lasts for 1/10 of a second before the image on the retina fades away. When I show the empty cage, a new image is formed on the retina and a new message is sent to the brain. Persistence of vision occurs again when I take the picture of the empty cage away. The image of the empty cage on the retina lasts for 1/10 of a second before it ?/ (what) fades away. The brain receiving a message for the 1/10 of a second before the image on the retina fades away is called persistence of ?/ vision.

If I twirl the card fast now, you see the bird in the cage. Why? When the bird side of the card is facing you, the brain receives a message from the image on the ?/ retina. After I turn the card around, the brain continues to get a message about the bird for 1/10 of a second. If I turn the card around before the 1/10 of a second is up, the brain will be getting two messages at the same time -- one message about the bird which was just shown and another message about the cage.

Thus when the two pictures are shown, one right after another and the second one is shown before 1/10 of a second is up, the brain will get two messages at the same time instead of just ?/ (how many) one.

Thus, when I twirl the card real fast, the retina gets an image of the bird and before 1/10 of a second is up, it gets another image, that of the cage. The retina sends two messages together to the ?/ brain. And if I keep twirling the card over and over real fast, it appears to us as if the bird were in the cage. Remember, we said that the image lasting on the retina for 1/10 of a second leads to persistence of ?/ vision. Persistence of vision means that we continue to see the bird side of the card, for 1/10 of a second even though the cage side of the card is facing us. When we twirl the card very fast, before the image of the bird can fade out from the retina, the image of the cage is also put on the retina. The two images on the retina at the same time seen over and over again make it appear as if the bird is in the ?/ cage.

Watch this. We saw the man's arm move. But in all these separate pictures the arm was not moving. How did we come to see movement when there is no movement in the picture? The arm on each page is in a slightly different position. Here the man's arm is in this position. On the next page it's in a slightly different position, and on the next page in still a ?/ (what kind of position) slightly different position. When I flip these pages rapidly and show all these slightly different positions in quick succession it works the same way that the bird and the cage worked. First you see one page and the image is still on the retina for 1/10 of a second, and already the image of the next page appears. If we flip the pages fast enough, the image of the second page appears on the retina before the image of the first page fades away. The image of the third page appears on the retina before the image of the second page ?/ (does what) fades away. The image of the fourth page appears on the retina before the image of the third page ?/ fades away. And so on to the end of the booklet.

All the images on the retina show the arm in slightly different positions. Images on the retina and the messages they send to the brain show a series or succession of the man's arm in slightly different ?/ positions. If a series or succession of pictures of the man's arm in slightly different positions are seen very rapidly, it appears to us as if the man were moving his arm. The motion is smooth because in each picture the man's arm is in a slightly different position. Because persistence of vision occurs for each image and each succeeding image is ever so slightly different, they blend together and the motion appears ?/ smooth. The man's arm appears to be in smooth motion but what we are actually seeing are separate pictures in which the man's arm is still or stationary, like this.

Each picture is a still or stationary picture with no ?/ movement. But if we see a very quick series of still or stationary pictures of a man with his arm in slightly different positions starting with his arm down here and ending up with his arm up here, the arm will appear to be ?/ moving.

The persistence of vision for 1/10 of a second enables us to see ?/ movement. When the pages are turned fast enough each slightly different position of the man's arm blends in with the last and it appears to us as a smooth ?/ movement.

Do you see any connection between the booklet we just watched and the way movies work? Watch me as I raise a glass to my mouth. That's a smooth motion, isn't it? We took a motion picture of me raising a glass the other day. Here's

the film of it. (Insert A -- 2 seconds -- no sound)

Let's look at a piece of the film. Each little square is called a frame. Each frame shows a single picture and each frame shows a picture that is slightly different from the next. Each of these squares on this strip of film is called a $\frac{1}{10}$ frame. Each frame shows my arm in a slightly different position. But all these are still pictures. There is no movement on the pictures. All the pictures show is my arm in slightly different $\frac{1}{10}$ positions. (Insert B -- approximately 8 seconds, no sound)

These pictures are still or stationary and don't show any $\frac{1}{10}$ movement. How do we see movement when the frames are merely a series of still pictures with objects in slightly different positions but with no movement in them?

Do you remember what we said about the bird and the empty cage? We said that an image lasting on the retina for $\frac{1}{10}$ of a second after we look at the picture of either the bird or the cage was called persistence of $\frac{1}{10}$ vision. The same thing happens when we look at still pictures like this. (Insert C -- approximately 4 seconds)

An image of this picture is formed in your eye on the part we call the $\frac{1}{10}$ retina. When we take away the picture, the image lasts on the retina for $\frac{1}{10}$ of a second longer and continues to send a message during that $\frac{1}{10}$ of a second to the $\frac{1}{10}$ brain. We call this persistence of $\frac{1}{10}$ vision. When we remove the first picture and then show you a second picture during the $\frac{1}{10}$ of a second that the first picture remained on the retina, the retina would send messages to the brain about two images instead of just one. In order to have messages to the brain about two images at the same time, the second picture must be seen after the first one is taken away within (how much time) $\frac{1}{10}$ of a second.

But movie film has pictures on each frame that are slightly different from one another. (Insert D -- approximately 4 seconds -- My arm is in one position in this picture. And in this picture it's in a slightly different position.)

If the first frame is removed and a second frame is shown during the $\frac{1}{10}$ of a second that the retina still has an image of the first frame, there will be two messages to the brain from the $\frac{1}{10}$ retina. Since the frames show my arm in slight different positions, the brain will get messages at the same time about two different positions of my arm. The brain will get two messages about my arm in two slightly different $\frac{1}{10}$ positions. If we show the film fast enough my arm will then appear to be moving smoothly from one position to the next. (Insert E -- approximately 2 seconds)

Let's run the film slowly now to show how the arm changes position from picture to picture. When run slowly the motion won't be smooth. It will be jerky. Watch. (Insert F -- approximately 18 $\frac{1}{2}$ seconds)

Each frame was a still or stationary picture and showed my arm in a slightly different $\frac{1}{10}$ position. There is no movement in each picture; each frame is a $\frac{1}{10}$ (what kind of picture) still picture.

When we show each frame slowly, you see my arm in different positions; but my arm doesn't appear to move smoothly from one position to the other. It appears jerky. When we show it fast my arm does appear to move smoothly.

(Insert G -- uses no sound)

When the speed of the film going through the movie projector is fast enough, my arm appears to ?/ move smoothly. Let's show the film slowly again and then speed it up a bit. (Insert H -- 18 1/2 seconds -- no sound)

Now let's show it a little faster. (Insert I -- 12 seconds -- no sound)

We see individual pictures a little faster. My arm changes positions but still doesn't appear to move smoothly. Let's do it a little faster still. (Insert J -- 12 seconds -- no sound)

My arm changes position faster and now appears to move a little smoother. But it is still jerky. Let's see it faster yet. (Insert K -- 6 seconds -- no sound)

My arm almost appears to be moving smoothly now. Let's run the projector even faster. (Insert L -- 4 seconds -- no sound)

Now let's run the projector at 24 frames a second, the normal speed. (Insert M -- 2 seconds -- no sound)

My arm moved smoothly when the projector ran at 24 frames a ?/ second. When the projector runs at regular speed or (how many frames a second) ?/ 24 frames a second, each new frame creates an image on the retina during the 1/10 of a second that the image of the preceding frame is on the retina. Each new frame creates an image on the retina before the old image has had a chance to fade away. Old images are replaced by new ones and are in turn replaced by still new ?/ images. Since each new frame shows a slightly different position of my arm, images on the retina show my arm in slightly different ?/ positions; but these pictures are shown so fast, one right after the other, before the image of the preceding picture has faded out, the image of the next one comes right on top of it; because they come so fast in this way, although the pictures are still or stationary pictures with no movement on the film, it nevertheless appears as if my arm were ?/ moving. Persistence of vision makes it possible for still pictures without movement on them to show movement -- such as my lifting up the glass.

When we show a succession of still pictures fast enough, movement can be seen on the screen due to the phenomenon we call persistence of ?/ vision.

How do we show a series or succession of pictures? We use a movie projector to show a series of pictures. Here is a model showing the parts inside a movie projector. This claw in the projector engages the film and pulls it down one frame at a time. Then the frame stays stationary for a fraction of a second while the picture is projected on the screen. Then the claw again engages the ?/ (what) the film and pulls it down ?/ (how many frames at a time) one frame at a time.

The new frame also stays stationary for a fraction of a ?/ second while it is projected. The film must stay still while it is being projected so the image on the screen is clear, and so it doesn't move on the screen. The projector pulls one frame at a time into position, shows it, and then moves on to the next so that the retina sees each new image before the old one fades away.

When a frame is projected on the screen we see a stationary picture for a fraction of a second. Then the projector shows us another stationary picture for the next fraction of a ?/ second. Each fraction of a second the projector shows

us a picture which is ?/ stationary. The projector shows a rapid series of stationary ?/ pictures. All these pictures are slightly different and are shown one at a time but fast enough so that the pictures blend together and we see movement. Slightly different pictures, if shown one at a time and fast enough will ?/ (what) blend and make us see ?/ movement.

The light from the projector shines through the picture so you can see it on the screen only when the picture is stationary. This shutter transmits light only when the picture is like this (Insert N -- 3 seconds --- no sound) or ?/ stationary.

While the film is moving or between frames like this (Insert O -- 3 seconds -- no sound) the shutter on the projector is in this position and doesn't transmit ?/ light. If it did we would only see a blur. The shutter transmits light only when the frame or picture is ?/ stationary.

(Insert P -- sound -- When the frame is stationary like this light comes through, when the film is moving to the next frame no light comes through, stationary, moving, stationary, moving. We just slowed down what happens. When the film is moving at its regular speed of 24 frames a second we don't see the dark frames -- we see only the pictures through which light is transmitted.)

Film on the projector travels fast, at 24 frames a second. But the light is transmitted only when each of those 24 frames is ?/ stationary. If the light were to come through while the film is moving, we wouldn't see a clear ?/ picture.

At 24 frames a second all the slightly different pictures on the film blend into each other and we see movement. We see movement when the frames move at ?/ (how many frames a second) 24 frames a second. That's because each frame shows us a picture of a slightly different position before the old position fades away on the part of the eye we called the ?/ retina. Remember we called this phenomenon of a slowly fading image, persistence of ?/ vision.

We see movement in movies when we see pictures that are ?/ stationary and that show slightly different ?/ positions. If these pictures are shown at ?/ (how many frames a second) 24, the pictures will blend and we will see smooth ?/ movement.

Script for Experimental Lesson

Insert A. (Let's watch a man try to lift this automobile by himself. As much as he tries, he isn't strong enough to lift it. Let's see if two people can lift the automobile. Now two men are trying to lift the automobile together. Together they just manage to lift it a tiny fraction. Now let's watch and see if this long board can help the man to lift the automobile all by himself. Watch. The man is pressing down on one end of the board with just one finger and the automobile is being lifted quite a bit by the other end of the board. Let's watch it again. The man presses down on one end of the board with just one finger. And at the other end, the automobile is lifted up into the air.)

Today we're going to find out how the long board we just saw made it possible for the man to lift the automobile with just one finger. Remember without the long board he couldn't raise the automobile at all even with both arms, and, even with the help of another person, he still couldn't lift the automobile.

To help you understand how the long board helped the man to raise the automobile so easily, every now and then during the lesson I'm going to ask some questions and I'll pause to let you fill in the answers. Every time I ask a question, a question mark will appear on the screen like this ?/. Then I'll pause a second or two and let you give the answer. When you see the question mark on the screen, say the answer right out loud. See if you can say the answer out loud before I do. O. K.?

Now if we had a powerful machine like this crane, we could lift an automobile with it, couldn't we? The crane is a machine which performs or does work for us. What do we mean when we say a machine performs or does work? A machine performs work when it lifts a heavy load like this up from the ground. Any time we lift a load up we have performed ?/ (what) WORK. Did you say work out loud before I did?

When I slide this book from one side of the table to another, I do so by applying a push to it. When I lift the book up from the table I do so by applying a pull to it. Whenever I apply a push or whenever I apply a pull to any object like this book, I'm able to move it. Objects are moved when we apply pushes or ?/ PULLS.

The objects are moved in the same direction as the push or pull. If I push this way, the book moves in the same direction as the push. If I pull in this direction, the book moves in the same direction as the pull. The book moves in the direction of the push or the pull. If I apply a push in this direction, the book moves in the same direction as the ?/ THE SAME DIRECTION AS THE PUSH.

Pushes and pulls have a name; they are called forces. Thus, when a push is applied to this book, we say that we have applied a pushing force to it. In the same way, when a pull is applied to this book, we can also say that we have applied a pulling ?/ (what) A PULLING FORCE. Forces either as a push or as a pull can make the book move. For example, the book was moved from down here to up here by applying a pulling force. We made the book move by ?/ (doing what to it) APPLYING A PULLING FORCE TO IT.

Whenever we apply a force to an object and the object moves in the same direction as the force - we have performed work. Let's define work in terms of forces.

The amount of work we perform is equal to the force we apply times the distance the object moves. If I apply a pushing force of one pound to a book and the book moves two feet in the same direction as the force, I have performed two foot pounds of work. The amount of force applied times the distance the object moves is equal to the amount of ?/ (what that we perform) THE AMOUNT OF WORK WE PERFORM.

Let's do another example. Let's lift this two pound book. It takes a two pound force to lift a two pound book. Similarly, in order to lift a three pound book we need a ?/ (what size force) A THREE POUND FORCE. We need a force equal to the weight of a load in order to lift it. In order to lift a 2000 pound automobile, we need ?/ (what) A 2000 POUND FORCE.

Getting back to books, how much work have we done when we lifted the two pound book two feet up ?/ (how many foot pounds of work) $2 \times 2 = ?$ - FOUR FOOT POUNDS OF WORK. It takes a two pound force to lift a two pound book. Two pound force $\times$ two feet = four foot pounds of work. We compute the amount of work performed by multiplying the force that's applied times the (what that the object is moved) ?/ FORCE TIMES THE DISTANCE THE OBJECT IS MOVED.

What then do we mean by work (what does work equal) ?/ WORK EQUALS FORCE $\times$ THE DISTANCE AN OBJECT MOVES.

Why do we use machines like the crane to do our work when they lift heavy loads? When loads are very heavy, very large forces are needed to lift them. As a matter of fact, we need a force that is as big as the weight of the load. If the load weighs 350 pounds we need a force of 350 to lift. Light loads require small forces to lift or move them. To lift or move large loads we need ?/ (what) LARGE FORCES.

Men aren't strong enough to apply a force that will be big enough to move a large or heavy load. He needs something that will increase forces for him so that they will be big enough. Therefore, machines are used to increase forces so that the forces will be big enough to move a heavy load. To move a heavy load we need a machine that will increase ?/ (what) A MACHINE THAT WILL INCREASE A FORCE. Machines help us because they (what do they do to forces) ?/ THEY INCREASE FORCES.

Insert B. (The man pushed the board with just his finger. This means he applied a small force with his finger at one end of the board and the board increased or magnified the force so that it was big enough at the other end to lift the heavy car. Therefore, the board acted as a machine to increase a force.)

Machines help us by increasing forces. The straight board increased a force and therefore we can call it a ?/ MACHINE. The board that was used was rigid - that is, we couldn't bend it. The rigid board served as a simple kind of machine which we call a lever. Levers consist of objects which cannot be bent. In other words, they are rigid. Any rigid object can be used as a lever. But, to be called a lever a board must be ?/ RIGID. The board is placed on a fulcrum. The board can be pivoted like this around the ?/ (what) AROUND THE FULCRUM. The rigid board is pivoted around ?/ (what) THE FULCRUM. Why do we call the lever a machine? A lever is a machine because when we apply a force at one end we increase the force at the other end.

In addition to being increased, the force was transmitted from one end of the board to the other end. The man pushed on one end and the force was transmitted to

the other end which lifted the automobile. Any lever transmits a force from one end to another. What happens to a force that is applied at one end ?/ IT IS TRANSMITTED TO THE OTHER END. A lever also increases forces.

A lever then does two things to forces. What two things does a lever do to forces? What does it do to the size of the force ?/ IT INCREASES THE FORCE. The force goes from one end to the other. That means the lever does what to the force?/ TRANSMITS IT FROM ONE END TO THE OTHER. In addition to transmitting a force from one end to the other and increasing the force, a lever sometimes changes the direction of a force. When I push down here - there is a push up at the other end. The direction of the force was changed. A lever changes the ?/ (what of a force) THE DIRECTION.

I want you to make a lever in your classrooms now. Take a ruler, a pencil, and a book. Put the zero end to the left like this. Put a pencil under the two-inch mark like this. Put the book at the zero end. Now push down at the 12-inch end. It's easy to push the book up, isn't it? You applied a downward force at the 12-inch end and the direction at the other end was up. The push down is called the applied force and the upward push is called the lifting force. The push down is which force ?/ (the applied or lifting force) THE APPLIED FORCE IS THE PUSH DOWN. The upward push is therefore the ?/ THE LIFTING FORCE.

Put the book on the left end of your ruler again. Put the pencil under the two-inch mark and now push down at the right end or 12-inch end. It's easy to push down, isn't it? Move the ruler to the eight-inch mark. Push down at the 12-inch mark again. Was your downward applied force smaller, the same, or bigger than before?/ IT WAS BIGGER.

We have just demonstrated the following principle: The closer the fulcrum is to the object we want to lift, the easier it is to lift it. What do we mean by easier? Easier means that we have to apply a smaller downward push at this end. When the fulcrum is close to the load, the applied downward force needed at this end is ?/ (large or small) SMALL. As the fulcrum moves away from the load, the applied downward force at this end in order to lift the load must be ?/ (what) GREATER. Put your ruler and book away now.

Insert C. (When the fulcrum is close to the automobile the man is applying a downward force with just one finger and is able to lift the car at the other end. Let's see it with the fulcrum a little farther away from the car. Now, the man has to apply a force with his whole hand in order to raise the car. He has to bear down harder than before. Let's move the fulcrum even farther away. Now he needs both hands to apply the downward force and he has to work pretty hard to raise the car.)

Let's see if we can explain why it's easier to push down on a lever and raise a heavy object when the fulcrum is nearer the load. We can show that the applied force times this length from the place the force is applied to the fulcrum is equal to the lift times this length from the place the lift occurs to the fulcrum.

Applied force times this length is equal to lifting force times this length. For example, I'm going to put a load of 15 pounds at this end of the lever, and I'm going to put the fulcrum two inches away from the load. All I need is an applied force of three pounds to lift the 15 pound load at the other end. Why? Let's look at our formula. The downward force is three pounds; this length is 10 inches.

The load weighs 15 pounds and therefore we need a lifting force of 15 pounds to raise it. The upward force is 15 pounds. This length from the end to the fulcrum is two inches. Three pounds times 10 inches = 30 - Fifteen pounds times two inches = 30. Thirty = thirty.

I'm going to move the fulcrum to the three inch mark now. We still have a 15 pound load at this end. How much of a force do we need at this end to lift the 15 pound load at the other end? Let's figure it out. The 15 pound load times three inches equals 45. The fulcrum is three inches from this end and therefore it's nine inches from this other end. Therefore, on this side of the equation we have nine times ?/ (what) NINE TIMES FIVE. We need a five pound downward force or push to lift the 15 pound load at the other end. Length x load = length x applied force.

How can we tell how much of a push we'll need in order to lift a given weight or load? I apply the force at this end. This length is twice as long as this length. In order to make this equation equal, the applied force will have to be one-half the weight of the load that is lifted. This length is eight inches. This length is four inches. This one is twice as long as this one. Therefore, at this end we need only half the force. It takes just a 10 pound force to lift a 20 pound load. The equation comes out equal then. This length is twice as long as this one. This force is one-half this one.

If this length were two and this length were 10, this length would be five times as long. We would only need one-fifth the force to lift the 20 pound weight. Since the load is 20 pounds, we'd need a downward force of one-fifth of ?/ (one-fifth of how many pounds) 20 POUNDS. Therefore, we need a downward force of ?/ (one-fifth of 20 is how much) FOUR POUNDS.

But do we get something for nothing when we apply a small force and move a big load? Let's look at this example. Although we need only 10 pounds to lift a 20 pound load -- or one-half its weight, we have to apply this 10 pound force over a distance twice as long as that which the load covers. I have to push down two inches to raise this load one inch. I have to push down four inches to raise this load ?/ (how many inches) TWO INCHES.

So we don't get something for nothing. In order to raise a heavy load with a small amount of push -- I can only move the load a small distance. I have to apply a small force over a large distance in order to be able to raise a heavy load ?/ (over what kind of distance) A SMALL DISTANCE. The lever increases the push on the load -- but the load only moves a small ?/ DISTANCE. This is so because work in must equal work out -- applied force x distance must equal ?/ (what) LOAD TIMES THE DISTANCE.

Insert D. (Even though the load moves just a little bit, machines are useful to us because without them we wouldn't be able to lift such heavy loads like the automobile.)

Script for Control Lesson

Insert A. (Let's watch a man try to lift this automobile by himself. As much as he tries, he isn't strong enough to lift it. Let's see if two people can lift the automobile. Now two men are trying to lift the automobile together. Together they just manage to lift it a tiny fraction. Now let's watch and see if this long board can help the man to lift the automobile all by himself. Watch. The man is pressing down on one end of the board with just one finger and the automobile is being lifted quite a bit by the other end of the board. Let's watch it again. The man presses down on one end of the board with just one finger. And at the other end, the automobile is lifted up into the air.)

Today we're going to find out how the long board we just saw made it possible for the man to lift the automobile with just one finger. Remember without the long board he couldn't raise the automobile at all even with both arms.

To help you understand how the long board helped the man to raise the automobile so easily, every now and then during the lesson I'm going to ask some questions and I'll pause to let you fill in the answers. Everytime I ask a question, a question mark will appear on the screen like this ?/. Then I'll pause a second or two and let you give the answer. When you see the question mark on the screen, say the answer right out loud. See if you can say the answer out loud before I do. O. K.?

Now if we had a powerful machine like this crane, we could lift an automobile with it couldn't we? The crane is a machine which performs or does work for us. What do we mean when we say a machine performs or does work? A machine performs work when it lifts a heavy load like this up from the ground. Any time we lift a load up we have performed ?/ (what) WORK. Did you say work out loud before I did?

When I slide this book from one side of the table to another I do so by applying a push to it. When I lift the book up from the table I do so by applying a pull to it. Whenever I apply a push or whenever I apply a pull to any object like this book, I'm able to move it. Objects are moved when we apply pushes or ?/ PULLS. The objects are moved in the same direction as the push or pull. The book moves in the direction of the push or pull. If I apply a push in this direction, the book moves in the same direction as the ?/ THE SAME DIRECTION AS THE PUSH.

Pushes and pulls have a name; they are called forces. Thus when a push is applied to this book, we say that we have applied a pushing force to it. In the same way, when a pull is applied to this book, we can also say that we have applied a pulling ?/ (what) A PULLING FORCE.

Forces either as a push or as a pull can make the book move. For example, the book was moved from down here to up here by applying a pulling force. We made the book move by ?/ (doing what) APPLYING A PULLING FORCE. Whenever we apply a force to an object and the object moves in the same direction as the force - we have performed work. Let's define work in terms of forces. The amount of work we perform is equal to the amount of force we apply to an object times the distance we move the object.

If I apply a pushing force of one pound to a book and the book moves two feet in the same direction as the force, I have performed two foot pounds of work. The amount of force applied times the distance the object moves is equal to the amount of ?/ (what that we perform) THE AMOUNT OF WORK WE PERFORM.

Let's do another example. Let's lift this two pound book. It takes a two pound force to lift a two pound book. Similarly, in order to lift a three pound book we need a ?/ (what size force) A THREE POUND FORCE. We need a force equal to the weight of a load in order to lift it. In order to lift a 2,000 pound automobile, we need ?/ (what) A 2,000 POUND FORCE.

Getting back to books, how much work have we done when we lifted the two pound book two feet up ?/ ($2 \times 2 = ?$) FOUR FOOT POUNDS OF WORK. We compute the amount of work performed by multiplying the force that's applied times the (what that the object is moved) ?/ FORCE TIMES THE DISTANCE THE OBJECT IS MOVED. What then do we mean by work (what does work equal) ?/ WORK EQUALS FORCE TIMES THE DISTANCE AN OBJECT MOVES.

Why do we use machines like the crane to do our work when they lift heavy loads? When loads are very heavy, very large forces are needed to lift or move them. Light loads require small forces to lift or move them. To lift or move heavy loads we need ?/ (what) LARGE FORCES. Men aren't strong enough to apply a force that will be big enough to move a heavy load. Therefore, machines are used to increase forces so that the forces will be big enough to move a heavy load. To move a heavy load we need a machine that will increase ?/ (what) A MACHINE THAT WILL INCREASE A FORCE.

Insert B. (The man pushed the board with just his finger. This means he applied a small force with his finger at one end of the board and the board increased or magnified the force so that it was big enough at the other end to lift the heavy car. Therefore, the board acted as a machine to increase a force.)

Machines help us by increasing forces. The straight board increased a force and therefore we can call it a ?/ MACHINE. The board was used as a simple kind of machine which we call a lever. The straight board in the film was rigid - that is we couldn't bend it.

Any rigid object can be used as a machine called a lever. To be called a lever a board must be ?/ RIGID. The rigid board is placed on a pivot or fulcrum. The board can be pivoted like this around the pivot or ?/ (what) AROUND THE FULCRUM. The rigid board is pivoted around ?/ (what) THE FULCRUM.

Why do we call the lever a machine? A lever is a machine because when we apply a force at one end we increase the force at the other end. In addition to being increased, the force was transmitted from one end of the board to the other end. The man pushed on one end and the force was transmitted to the other end which lifted the automobile. Any lever transmits a force from one end to another. A lever also increases forces.

A lever then does two things to forces. It does what to forces ?/ TRANSMITS AND INCREASES FORCES. In addition to transmitting and increasing a force, a lever sometimes changes the direction of a force. When I push down here - there is a push up at the other end. The direction of the force was changed. A lever changes the ?/ (what of a force) THE DIRECTION.

I want you to make a lever in your classrooms now. Take a ruler, a pencil, and a book. Put the zero end to the left like this. Put a pencil under the two-inch mark like this. Put the book at the zero end. Now push down at the 12-inch end. It's easy to push the book up isn't it? You applied a downward force at the 12-inch end and the direction at the other end was up.

The push down is called the applied force and the upward push is called the lifting force. The push down is which force ?/ (the applied or lifting force) THE APPLIED FORCE IS THE PUSH DOWN. The upward push is therefore the ?/ THE LIFTING FORCE.

Put the book on the left end of your ruler again. Put the pencil under the two-inch mark and now push down at the right end or 12-inch end. It's easy to push down, isn't it? Move the ruler to the eight-inch mark. Push down at the 12-inch mark again. Was your downward applied force smaller, the same, or bigger than before ?/ IT WAS BIGGER.

We have just demonstrated the following principle: The closer the fulcrum is to the object we want to lift, the easier it is to lift it. What do we mean by easier? Easier means that we have to apply a smaller downward push at this end. When the fulcrum is close to the load, the applied downward force needed at this end is ?/ (large or small) SMALL. As the fulcrum moves away from the load, the applied downward force at this end in order to lift the load must be ?/ (what) GREATER. Put your ruler and book away now.

Insert C. (When the fulcrum is close to the automobile the man is applying a downward force with just one finger and is able to lift the car at the other end. Let's see it with the fulcrum a little farther away from the car. Now, the man has to apply a force with his whole hand in order to raise the car. He has to bear down harder than before. Let's move the fulcrum even farther away. Now he needs both hands to apply the downward force and he has to work pretty hard to raise the car.)

Let's see if we can explain why it's easier to push down on a lever and raise a heavy object when the fulcrum is nearer the load. We can show that the applied force times this length from the place the force is applied to the fulcrum is equal to the lift times this length from the place the lift occurs to the fulcrum. Applied force times this length is equal to lifting force times this length.

For example, I'm going to put a load of 15 pounds at this end of the lever, and I'm going to put the fulcrum two inches away from the load. All I need is an applied force of three pounds to lift the 15 pound load at the other end. Why? Let's look at our formula. The downward force is three pounds - times 10 inches. The upward force is 15 pounds. This length from the end to the fulcrum is two inches. Fifteen times two equals - thirty - thirty.

I'm going to move the fulcrum to the three-inch mark now. We still have a 15 pound load at this end. How much of a force do we need at this end? Let's figure it out. The 15 pound load times three inches equals 45. The fulcrum is three inches from this end and therefore it's nine inches from this other end. Therefore on this side of the equation we have nine times ?/ (what) NINE TIMES FIVE. We need a five pound downward force or push. Length times load equals length times applied force or push.

How can we tell how much of a push we'll need in order to lift a given weight or load? I apply the force at this end. This length is twice as long as this length. Therefore I need only one-half the force. This length is eight inches. This length is four inches. This one is twice as long as this one. Therefore at this end we need only half the force. It takes just a 10 pound force to lift a 20 pound load. If this length were two and this length were 10, this length would be five times as long. We would only need one-fifth the force to lift the 20

pound weight. Since the load is 20 pounds, we'd need a downward force of one-fifth of ?/ (one-fifth of how many pounds) 20 POUNDS. Therefore we need a downward force of ?/ (how many pounds) FOUR POUNDS.

But do we get something for nothing when we apply a small force and move a big load? Let's look at this example. Although we need only 10 pounds to lift a 20 pound load -- or one-half its weight, we have to apply this 10 pound force over a distance twice as long as that which the load covers. I have to push down two inches to raise this load one inch. I have to push down four inches to raise this load ?/ (how many inches) TWO INCHES.

So we don't get something for nothing. In order to raise a heavy load with a small amount of push -- I can only move the load a small distance. I have to apply a small force over a large distance in order to be able to raise a heavy load ?/ (what kind of distance) A SMALL DISTANCE. The lever increases the push on the load -- but the load only moves a small ?/ DISTANCE. This is so because work in must equal work out -- applied force times distance must equal ?/ (what) LOAD TIMES THE DISTANCE.

Insert D. (Even though the load moves just a little bit, machines are useful to us because without them we wouldn't be able to lift such heavy loads like the automobile.)

APPENDIX B

Achievement Tests

1. Tests on "Newton's Laws"
 - a. pre-tests (Form A and B) pp. B- 2 - B- 9
 - b. immediate and delayed post-tests pp. B-10 - B-17

2. Tests on "Movies"
 - a. pre-tests (Form A and B) pp. B-18 - B-23
 - b. immediate post-test pp. B-24 - B-27
 - c. delayed post-test pp. B-28 - B-31

3. Tests on "Levers"
 - a. pre-test pp. B-32 - B-35
 - b. immediate and delayed post-test pp. B-36 - B-39

NEWTON'S LAWS

ACHIEVEMENT TEST

Pre-Test

WQED

Junior High School Science Quiz

Form A

Name _____

Grade _____
7th or 8th

School _____

PART I: 4 minutes

Instructions: Answer the following questions in your own words. You will be allowed four (4) minutes. If you finish before this time, wait until I tell you to go on to the next part.

A. In your own words describe what Newton's law of inertia means.

B. In your own words describe what Newton's law of action and reaction means.

PART II - FILL-INS 7 minutes

Instructions: In the blanks below, fill in the word or words which make the sentence correct and complete.

Example: When water freezes it turns into _____.
(Write in your answer; if you wrote ice, you are correct.)

- 1a. Newton's laws relate forces to _____ in motion.
- 2a. _____ is a change of motion.
- 3a. Gravity is an example of a pulling _____.
- 4a. _____ is a change of place or position.
- 5a. The larger the mass of an object the _____ it will be accelerated by the same force.
- 6a. Pushes and pulls are examples of _____.
- 7a. Acceleration means an increase in _____ or a decrease in _____.
- 8a. It requires a _____ to change the motion of an object.
- 9a. If you give a block of wood a shove, it moves and then stops. The force that causes the block to stop was the force of _____.
- 10a. If two objects are each acted on by equal forces, the object with _____ mass will be accelerated _____.
- 11a. The tendency of objects to remain still, if it's still to begin with, is called _____.

PART III - MULTIPLE CHOICE ITEMS 4 minutes

Instructions: Each of the incomplete statements or questions below is followed by several possible answers. In the space provided put a check next to the answer you think is best.

Example: Water that is heated above the boiling point will turn into

- ☐ a solid.
- ☒ steam.
- ☐ ice.

- 12a. The laws of motion we use today were discovered by
- ☐ Aristotle.
 - ☐ Socrates.
 - ☐ Galileo.
 - ☐ Newton.
- 13a. As a man jumped from a rowboat onto a pier the boat moved away from the pier. This illustrates the law of
- ☐ inertia.
 - ☐ acceleration.
 - ☐ action and reaction.
 - ☐ all of the above
 - ☐ none of the above
- 14a. The law of inertia is exemplified by a
- ☐ rock falling off a cliff.
 - ☐ book lying on a table.
 - ☐ ball rolling down an incline.
 - ☐ all of the above.
 - ☐ none of the above.
- 15a. An example of a pulling force is
- ☐ a car colliding with another car.
 - ☐ gravity.
 - ☐ a ball rolling into bowling pins.
 - ☐ all of the above.
 - ☐ none of the above.
- 16a. An example of a force acting on an object is
- ☐ a ball rolling down a hill.
 - ☐ the throwing of a football.
 - ☐ a sled coming to a stop.
 - ☐ all of the above.
 - ☐ none of the above.
- 17a. A ball rolling down a hill
- ☐ is being acted upon by a force.
 - ☐ tends to accelerate.
 - ☐ changes its speed of motion.
 - ☐ all of the above.
 - ☐ none of the above.

18a. Acceleration is shown by a

- ☐ block of wood sliding on a table.
- ☐ man diving off a cliff.
- ☐ ball rolled up an incline.
- ☐ all of the above.
- ☐ none of the above.

NEWTON'S LAWS

ACHIEVEMENT TEST

Pre-Test

WQED

Junior High School Science Quiz

Form B

Name _____

Grade _____
7th or 8th

School _____

PART I: 4 minutes

Instructions: Answer the following questions in your own words. You will be allowed four (4) minutes. If you finish before this time, wait until I tell you to go on to the next part.

- A. In your own words describe what Newton's law of acceleration means.
- B. In your own words describe what Newton's law of action and reaction means.

PART II - FILL-INS 7 minutes

Instructions: In the blanks below, fill in the word or words which make the sentence correct and complete.

Example: When water freezes it turns into _____.
(Write in your answer; if you wrote ice, you are correct.)

- 1b. Forces bring about changes in _____.
- 2b. Acceleration is a _____ of motion.
- 3b. Gravity is an example of a _____ force.
- 4b. Motion means a _____ of _____.
- 5b. The larger the mass of an object, the less it will be accelerated by the _____ force.
- 6b. Friction and gravity are examples of _____.
- 7b. Acceleration always takes place in the _____ direction as the causing force.
- 8b. If there is no force there will be no _____ of motion.
- 9b. A ball rolls down an inclined plane. A force is making the ball _____ and we call that force _____.
- 10b. The _____ the force acting on an object, the _____ the acceleration.
- 11b. For every action there is an equal and _____ reaction.

PART III - MULTIPLE CHOICE ITEMS 4 minutes

Instructions: Each of the incomplete statements or questions below is followed by several possible answers. In the space provided put a check next to the answer you think is best.

Example: Water that is heated above the boiling point will turn into

- ☐ a solid.
- ☒ steam.
- ☐ ice.

- 12b. Newton's laws are concerned with
- ☐ inertia.
 - ☐ acceleration.
 - ☐ action and reaction.
 - ☐ all of these.
 - ☐ none of these.
- 13b. If object A is acted upon by object B with a force of 10 pounds, object A will certainly
- ☐ change the direction of its motion.
 - ☐ gain in speed.
 - ☐ have a mass of 10 pounds.
 - ☐ rotate.
 - ☐ exert an opposite force of 10 pounds on object B.
- 14b. A moving object not acted upon by any force tends to
- ☐ slow down.
 - ☐ change direction.
 - ☐ accelerate.
 - ☐ all of the above.
 - ☐ none of the above.
- 15b. Which of the following is an example of a force?
- ☐ friction
 - ☐ mass
 - ☐ acceleration
 - ☐ motion
 - ☐ a heavy weight
- 16b. When a force causes an object to move the object goes
- ☐ in the same direction as the force.
 - ☐ in the opposite direction from the force.
 - ☐ sometimes in the same direction and sometimes in the opposite direction.
- 17b. When a rifle is fired, the bullet is accelerated more than the rifle because the bullet
- ☐ is acted upon by a greater force.
 - ☐ is smaller in mass.
 - ☐ encounters less friction.
 - ☐ is less affected by gravity.

18b. A driver increased the speed of his car from 20 to 40 miles per hour.
This is an example of

- ☐ action.
- ☐ reaction.
- ☐ acceleration.
- ☐ inertia.

NEWTON'S LAWS

ACHIEVEMENT TEST

Immediate and Delayed
Post-Tests

WQED

Junior High School Science Quiz
Form A

Name _____

Grade _____
7th or 8th

School _____

PART I: 4 minutes

Instructions: Answer the following questions in your own words. You will be allowed four (4) minutes. If you finish before this time, wait until I tell you to go on to the next part.

- A. In your own words describe what Newton's law of inertia means.
- B. In your own words describe what Newton's law of action and reaction means.

PART II - FILL-INS 7 minutes

Instructions: In the blanks below, fill in the word or words which make the sentence correct and complete.

Example: When water freezes it turns into _____.
(Write in your answer; if you wrote ice, you are correct.)

- 1a. Newton's laws relate _____ to _____ in motion.
- 2a. The tendency of objects to remain still, if they are still to begin with, is called _____.
- 3a. A ball rolled up an incline tends to slow down as a result of _____ which is a pulling _____.
- 4a. We use the word _____ to describe a change of place or position.
- 5a. The greater the _____ of an object the _____ it will be accelerated by the same force.
- 6a. For every action there is an equal and _____ reaction.
- 7a. Acceleration means an increase in the rate of _____ or a decrease in the rate of _____.
- 8a. It requires a _____ to _____ the motion of an object.
- 9a. If you give a block of wood a shove, it moves and then stops. The block was stopped by the _____ of _____.
- 10a. If two objects are each acted on by equal forces, the object with the _____ mass will be accelerated _____.
- 11a. We define _____ as a change of motion.
- 12a. Pushes and pulls are examples of _____.

PART III - MULTIPLE CHOICE ITEMS 4 minutes

Instructions: Each of the incomplete statements or questions below is followed by several possible answers. In the space provided put a check next to the answer you think is best.

Example: Water that is heated above the boiling point will turn into

- ☐ a solid.
- ☐ steam.
- ☐ ice.

13a. Newton's laws are concerned with objects

- ☐ in uniform motion.
- ☐ at rest.
- ☐ in accelerated motion.
- ☐ acted on by unbalanced forces.
- ☐ all of these

14a. The law of inertia is exemplified by a

- ☐ rock falling off a cliff.
- ☐ book lying on a table.
- ☐ ball rolling down an incline.
- ☐ all of the above.
- ☐ none of the above.

15a. An example of a pulling force is

- ☐ a car colliding with another car.
- ☐ gravity.
- ☐ a ball rolling into bowling pins.
- ☐ all of the above.
- ☐ none of the above.

16a. An example of a force acting on an object is

- ☐ a ball rolling down a hill.
- ☐ the throwing of a football.
- ☐ a sled coming to a stop.
- ☐ all of the above.
- ☐ none of the above.

17a. A ball rolling down a hill

- ☐ is being acted upon by a force.
- ☐ tends to accelerate.
- ☐ changes its speed of motion.
- ☐ all of the above.
- ☐ none of the above.

18a. When a rifle is fired, the bullet is accelerated more than the rifle because the bullet

- ☐ is acted upon by a greater force.
- ☐ is smaller in mass.
- ☐ encounters less friction.
- ☐ is less affected by gravity.

19a. A ball rolling on a flat table will tend to

- ☐ change its motion.
- ☐ change its direction.
- ☐ keep rolling at the same rate.
- ☐ be acted on by gravity.

Immediate and Delayed
Post-Tests

WQED

Junior High School Science Quiz

Form B

Name _____

Grade _____

School _____

7th or 8th

PART I: 4 minutes

Instructions: Answer the following questions in your own words. You will be allowed four (4) minutes. If you finish before this time, wait until I tell you to go on to the next part.

- A. In your own words describe what Newton's law of acceleration means.
- B. In your own words describe what Newton's law of action and reaction means.

PART II - FILL-INS 7 minutes

Instructions: In the blanks below, fill in the word or words which make the sentence correct and complete.

Example: When water freezes it turns into _____.
(Write in your answer; if you wrote ice, you are correct.)

- 1b. _____ bring about _____ in motion.
- 2b. For every action there is an _____ and _____ reaction.
- 3b. The force of _____ does not act on an object moving at a uniform rate of motion.
- 4b. We define motion as a _____ of _____.
- 5b. The larger the _____ of an object, the less it will be accelerated by the _____ force.
- 6b. Objects sliding on a flat surface are stopped by the _____ of _____.
- 7b. _____ always takes place in the same _____ as the causing force.
- 8b. If there is no _____ there will be no _____ of motion.
- 9b. The acceleration of a _____ ball is brought about by a force we call _____.
- 10b. The _____ the force acting on an object, the _____ the acceleration.
- 11b. Acceleration is a _____ of _____.
- 12b. The tendency of objects to continue moving once they are in motion is called _____.

PART III - MULTIPLE CHOICE ITEMS 4 minutes

Instructions: Each of the incomplete statements or questions below is followed by several possible answers. In the space provided put a check next to the answer you think is best.

Example: Water that is heated above the boiling point will turn into

- ☐ a solid.
- ☐ steam.
- ☐ ice.

- 13b. As a man jumped from a rowboat onto a pier the boat moved away from the pier. This illustrates the law of
- ☐ inertia.
 - ☐ acceleration.
 - ☐ action and reaction.
 - ☐ all of the above.
 - ☐ none of the above.
- 14b. If object B exerts a force of 10 pounds on object A, object A will certainly
- ☐ change the direction of its motion.
 - ☐ gain in speed.
 - ☐ have a mass of 10 pounds.
 - ☐ rotate.
 - ☐ exert an opposite force of 10 pounds on object B
- 15b. A moving object not acted upon by any force tends to
- ☐ slow down.
 - ☐ change direction.
 - ☐ accelerate.
 - ☐ all of the above.
 - ☐ none of the above.
- 16b. Which of the following is an example of a force?
- ☐ acceleration
 - ☐ friction
 - ☐ a heavy weight
 - ☐ mass
 - ☐ motion
- 17b. When a force causes an object to move the object goes
- ☐ in the same direction as the force.
 - ☐ in the opposite direction from the force.
 - ☐ sometimes in the same direction and sometimes in the opposite direction.
- 18b. Acceleration is shown by a
- ☐ block of wood sliding on a table.
 - ☐ man diving off a cliff.
 - ☐ ball rolled up an incline.
 - ☐ all of the above.
 - ☐ none of the above.

19b. A driver increased the speed of his car from 20 to 40 miles per hour.
This is an example of

- ☐ action.
- ☐ reaction.
- ☐ acceleration.
- ☐ inertia.

MOVIES

ACHIEVEMENT TEST

Pre-Test

WQED

Junior High School Science

Form A

School _____

Name _____

Grade _____

7th or 8th

PART I Answer the following questions in your own words.

1. The most interesting thing about movies is that they really don't move at all. What do we mean by that?
2. What is "persistence of vision"?
3. If you saw a movie in which people were walking in jerky steps, what would you say the trouble was?

PART II - MULTIPLE CHOICE ITEMS

Pick out what you think is the best answer in the following questions and put a check mark ✓ alongside it.

1. When we see, a certain part of our eye sends a message to the brain. That part of the eye is the
☐ a. pupil.
☐ b. iris.
☐ c. retina.
☐ d. lens.
☐ e. None of the above.
2. A part in the movie projector pulls the film into position one frame at a time in order that each picture might be
☐ a. seen clearly.
☐ b. stationary for a fraction of a second.
☐ c. Both of the above.
☐ d. Neither of the above.
3. If the shutter in the movie projector works properly, the light flashes on the film
☐ a. only when the frames are moving.
☐ b. only when the picture shows daylight.
☐ c. all the time.
☐ d. only when the frames are stationary.
4. If the shutter in the movie projector let the light through the film all the time, the movie would appear
☐ a. too fast.
☐ b. too bright.
☐ c. clear.
☐ d. blurred.
☐ e. smooth.
5. If our eye could keep an image twice as long as it normally does, we would probably run the film
☐ a. twice as fast.
☐ b. half as fast.
☐ c. just as fast.
☐ d. either faster or slower.
☐ e. depends on the scene.
6. Smooth movement results when we see
☐ a. a series of slightly different scenes.
☐ b. 24 frames a second.
☐ c. light being projected only when the film is stationary.
☐ d. All of the above.
☐ e. None of the above.

7. Imagine a card with a fence drawn on one side and a jumping horse on the other side. If you were to twirl the card quickly, what would you see?

- ☐ a. first the fence and then the horse
- ☐ b. first the horse and then the fence
- ☐ c. the horse jumping over the fence
- ☐ d. a blur
- ☐ e. neither the horse nor the fence

8. In order to have smooth motion in movies, we must film a series of scenes each

- ☐ a. slightly different but shown quickly.
- ☐ b. slightly different but shown slowly.
- ☐ c. the same but shown quickly.
- ☐ d. the same but shown slowly.
- ☐ e. very much different from the last.

MOVIES

ACHIEVEMENT TEST

Pre-Test

WQED

Junior High School Science

Form B

School _____

Name _____

Grade _____
7th or 8th

PART I Answer the following questions in your own words.

1. If you saw a movie that was blurred, what would you say was the trouble?
2. Imagine a movie showing a man diving from a diving board into a pool of water. If you held the film in your hand and looked at the individual pictures or frames on the roll of film, what would you see? Describe a series of three or four frames..
3. How many frames are shown in one second in sound movies?
4. How long does our eye keep an image after we stop seeing a picture?

PART II - MULTIPLE CHOICE ITEMS

Pick out what you think is the best answer in the following questions and put a check mark ✓ alongside it.

1. When projected on the screen, individual frames
 - ☐ a. move all the time.
 - ☐ b. are upside down.
 - ☐ c. stand still for a fraction of a second.
 - ☐ d. None of the above.
2. Still pictures showing different stationary positions of a man raising a glass to his mouth will make it appear as if the man were actually raising the glass if each picture is
 - ☐ a. slightly different from the last.
 - ☐ b. shown within 1/10 of a second after the last one.
 - ☐ c. shown stationary for a fraction of a second.
 - ☐ d. All of the above.
 - ☐ e. None of the above.
3. The camera shutter lets the light on the picture
 - ☐ a. only for a fraction of a second for each frame.
 - ☐ b. all the time the frames move.
 - ☐ c. for 24 seconds on each frame.
 - ☐ d. when each frame is stationary.
 - ☐ e. Both (a) and (d) are correct.
4. The shutter in a movie projector is so arranged that it
 - ☐ a. transmits light only when the film is moving.
 - ☐ b. shuts out light when the film is stationary.
 - ☐ c. Both of the above.
 - ☐ d. Neither of the above.
5. If we ran movie film at half its normal speed, we would see
 - ☐ a. smoother motion.
 - ☐ b. slow motion.
 - ☐ c. jerky motion.
 - ☐ d. speeded-up motion.
 - ☐ e. regular motion with no sound.
6. To make a clear moving picture, each frame should be projected
 - ☐ a. several times quickly.
 - ☐ b. several times slowly.
 - ☐ c. stationary for a very short time.
 - ☐ d. stationary for several minutes.
 - ☐ e. a few times slowly.
7. Persistence of vision makes successive images
 - ☐ a. appear darker than the scene.
 - ☐ b. appear brighter than the scene.
 - ☐ c. blend in a continuous moving picture.
 - ☐ d. appear distinct from each other.
 - ☐ e. All of the above.

8. Movies are made of a

- ☐ a. quick succession of still pictures.
- ☐ b. slow succession of still pictures.
- ☐ c. fast succession of moving pictures.
- ☐ d. slow succession of moving pictures.

9. If our eye could keep the image twice as long and we ran the film half as fast, the picture would be

- ☐ a. brighter.
- ☐ b. worse than ordinarily.
- ☐ c. better than ordinarily.
- ☐ d. just as good.
- ☐ e. blurred.

MOVIES

ACHIEVEMENT TEST

Immediate Post-Test

WQED

Junior High School Science

Name _____

Grade _____
7th or 8th

School _____

PART I: 3 minutes

Instructions: Answer the following questions in your own words.

1. How many frames are shown in one second in sound movies?
2. How long does our eye keep an image after we stop seeing a picture?
3. What is "persistence of vision"?

PART II - MULTIPLE CHOICE ITEMS

10 minutes

Instructions: Pick out what you think is the best answer in the following questions and put a check mark ✓ alongside it.

1. When we see, a certain part of our eye sends a message to the brain. That part of the eye is the
☐ a. pupil.
☐ b. iris.
☐ c. retina.
☐ d. lens.
☐ e. None of the above.
2. A part in the movie projector pulls the film into position one frame at a time in order that each picture might be
☐ a. seen clearly.
☐ b. stationary for a fraction of a second.
☐ c. Both of the above.
☐ d. Neither of the above.
3. If the shutter in the movie projector works properly, the light flashes through the film onto the screen
☐ a. only when the frames are moving.
☐ b. only when the picture shows daylight.
☐ c. only when the frames are stationary.
☐ d. only on every other frame.
☐ e. all the time.
4. In a movie that shows a man throwing a ball, the man's arm will be in a slightly different position on
☐ a. each new frame.
☐ b. every other frame.
☐ c. every tenth frame.
☐ d. every twenty-fourth frame.
☐ e. None of the above.
5. When we say that persistence of vision occurs, we mean that
☐ a. we see smooth movement.
☐ b. we can see objects in slightly different positions.
☐ c. images last on the retina for 1/10 of a second.
☐ d. we can distinguish 24 separate frames a second.
☐ e. the retina sends repeated messages to the brain.
6. If you looked at an individual frame on a strip of motion picture film, you would see
☐ a. no motion at all.
☐ b. a tiny bit of motion.
☐ c. a moderate amount of motion.
☐ d. a large amount of motion.

7. Smoothness of movement results when we have
- ☐ a. a series of slightly different scenes.
 - ☐ b. enough speed -- about 24 frames a second.
 - ☐ c. each frame held stationary for a fraction of a second.
 - ☐ d. All of the above.
 - ☐ e. None of the above.
8. Images of individual frames when projected on the screen
- ☐ a. move all the time.
 - ☐ b. move part of the time and stand still part of the time.
 - ☐ c. stand still for a fraction of a second.
 - ☐ d. None of the above.
9. Still pictures showing different stationary positions of a man raising a glass to his mouth will make it appear as if the man were actually raising the glass if each picture is
- ☐ a. slightly different from the last.
 - ☐ b. shown within 1/10 of a second after the last one.
 - ☐ c. shown stationary for a fraction of a second.
 - ☐ d. All of the above.
 - ☐ e. None of the above.
10. The shutter in a movie projector is so arranged that it
- ☐ a. transmits light only when the film is moving.
 - ☐ b. shuts out light when the film is stationary.
 - ☐ c. Both of the above.
 - ☐ d. Neither of the above.
11. Persistence of vision makes successive images
- ☐ a. appear darker than the scene.
 - ☐ b. blend and all the images look alike.
 - ☐ c. blend in a continuous moving picture.
 - ☐ d. appear different from each other.
 - ☐ e. None of the above.
12. If the shutter in the movie projector let the light through the film all the time, the movie would appear
- ☐ a. normal.
 - ☐ b. too bright.
 - ☐ c. clearer.
 - ☐ d. blurred.
 - ☐ e. smooth.
13. In order to have smooth motion in movies, the series of pictures on the film must be
- ☐ a. all the same.
 - ☐ b. slightly different from each other.
 - ☐ c. greatly different from each other.
 - ☐ d. clear, but the difference between them doesn't matter.
 - ☐ e. slightly different every third frame.

PART III 5 minutes

Answer the following questions in your own words.

1. The most interesting thing about movies is that they really don't move at all. What do we mean by that?

2. Imagine a movie showing a man diving from a diving board into a pool of water. If you held the film in your hand and looked at the individual pictures or frames on the roll of film, what would you see? Describe a series of three or four frames.

MOVIES

ACHIEVEMENT TEST

Delayed Post-Test

WQED

Junior High School Science

Name _____

Grade _____

School _____

7th or 8th

PART I: 9 minutes

Instructions: Answer the following questions in your own words.

1. What is "persistence of vision"?
2. How does persistence of vision make it possible for us to see people move about in movies?
3. "The most interesting thing about movies is that they really don't move at all." What do we mean by that?
4. Imagine a movie showing a man diving from a diving board into a pool of water. If you held the film in your hand and looked at the individual pictures or frames on the roll of film, what would you see? Describe what you would see on a series of three or four frames.

PART II - MULTIPLE CHOICE ITEMS 9 minutes

Instructions: Pick out what you think is the best answer in the following questions and put a check mark ☒ alongside it.

1. The retina is the part of the eye
 - ☐ a. on which an image is formed.
 - ☐ b. which retains an image for 1/10 of a second.
 - ☐ c. which sends messages to the brain.
 - ☐ d. on which several images can be formed, one right after the other.
 - ☐ e. All of the above.
2. In a movie projector, the film is pulled into position and
 - ☐ a. light is transmitted when the image on the screen moves.
 - ☐ b. is held stationary for 1/10 second.
 - ☐ c. is held stationary for 24 frames.
 - ☐ d. just at that moment we see a different position.
 - ☐ e. None of the above.
3. If the shutter in the movie projector works properly, the light flashes through the film onto the screen
 - ☐ a. only when the picture shows movement.
 - ☐ b. only when the picture shows no movement.
 - ☐ c. only when the frames are moving.
 - ☐ d. only when the frames are stationary.
 - ☐ e. all the time.
4. In a movie that shows a man throwing a ball, the man's arm will be in a slightly different position on
 - ☐ a. every eighth frame.
 - ☐ b. every fourth frame.
 - ☐ c. every tenth frame.
 - ☐ d. every twenty-fourth frame.
 - ☐ e. None of the above.
5. When we say that persistence of vision occurs, we mean that
 - ☐ a. we see smooth movement.
 - ☐ b. we can see objects in slightly different positions.
 - ☐ c. images last on the retina for 1/10 of a second.
 - ☐ d. we can distinguish 24 different frames a second.
 - ☐ e. the retina sends repeated messages to the brain.
6. If you looked at an individual frame on a strip of motion picture film, you would see
 - ☐ a. no motion at all.
 - ☐ b. a tiny bit of motion.
 - ☐ c. a moderate amount of motion.
 - ☐ d. a large amount of motion.
 - ☐ e. the amount of motion depends on what the people are doing.

7. Smoothness of movement results when we have
- ☐ a. a series of slightly different scenes.
 - ☐ b. enough speed -- about 24 frames a second.
 - ☐ c. each frame held stationary for a fraction of a second.
 - ☐ d. a blending of slightly different images on the retina.
 - ☐ e. All of the above.
8. Images of individual frames when projected on the screen
- ☐ a. move all the time.
 - ☐ b. move part of the time and stand still part of the time.
 - ☐ c. stand still for a fraction of a second.
 - ☐ d. move when light is projected on the screen.
 - ☐ e. None of the above.
9. Persistence of vision makes successive images
- ☐ a. appear to be similar because they are stationary.
 - ☐ b. blend and all the images look alike.
 - ☐ c. blend in a continuous moving picture.
 - ☐ d. appear different from each other.
 - ☐ e. appear to move in the same way.
10. The shutter in a movie projector is so arranged that it
- ☐ a. transmits light only when the film is moving.
 - ☐ b. shuts out light when the film is stationary.
 - ☐ c. transmits light just before the frame is pulled into position.
 - ☐ d. All of the above.
 - ☐ e. None of the above.
11. Still pictures showing different stationary positions of a man raising a glass to his mouth will make it appear as if the man were actually raising the glass if each picture is
- ☐ a. slightly different from the last.
 - ☐ b. shown within 1/10 of a second after the last one.
 - ☐ c. shown stationary for a fraction of a second.
 - ☐ d. All of the above.
 - ☐ e. None of the above.
12. The action of the shutter is timed so as to
- ☐ a. transmit light just part of the time.
 - ☐ b. work together with the movement of the film.
 - ☐ c. make a clear picture possible.
 - ☐ d. All of the above.
 - ☐ e. None of the above.
13. The smoothness and clearness of movement we see in movies depends on
- ☐ a. persistence of vision.
 - ☐ b. slight differences of position in each frame.
 - ☐ c. each frame being held stationary.
 - ☐ d. the blending of still images.
 - ☐ e. All of the above.

14. When we show movies at 24 frames a second, the movement we see will be smooth. The main reason for this is that at this speed
- ☐ a. we have the most time to see clearly.
 - ☐ b. each image has had time to fade away before the next one is formed.
 - ☐ c. each image does not fade away before the next one is formed.
 - ☐ d. the retina can record smoother movement.
 - ☐ e. the retina works best.
15. When movies are shown at a speed of 24 frames a second
- ☐ a. old images have time to be replaced by new ones.
 - ☐ b. old images have adequate time to fade away.
 - ☐ c. a series of new images is formed.
 - ☐ d. new images are formed before old ones have faded away.
 - ☐ e. None of the above.
16. In order to see movement in movies, pictures of objects in slightly different positions must be shown
- ☐ a. one at a time.
 - ☐ b. very rapidly.
 - ☐ c. in a correct series.
 - ☐ d. All of the above.
 - ☐ e. None of the above.
17. If two different images are repeatedly formed on the retina very fast, we will
- ☐ a. not be able to see either one.
 - ☐ b. not be able to see a slightly different image.
 - ☐ c. not be able to see a very different image.
 - ☐ d. see a blending of the two.
 - ☐ e. see first one for 1/10 of a second, and then the other for 1/10 of a second.
18. When we stop looking at an object, the image on the retina
- ☐ a. fades away immediately.
 - ☐ b. fades away before a new image is formed.
 - ☐ c. lasts until a slightly different image replaces it.
 - ☐ d. lasts until a completely different image replaces it.
 - ☐ e. lasts for a fraction of a second.

LEVERS

ACHIEVEMENT TEST

Pre-Test

WQED

Junior High School Science

Name _____

Grade _____
7th or 8th

School _____

PART I: 4 minutes

Instructions: Answer the following questions in your own words.

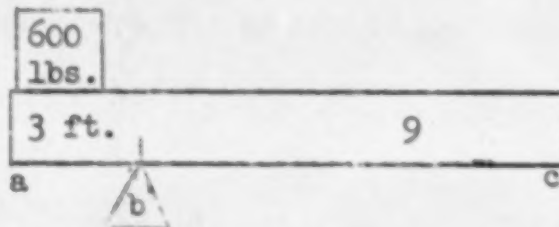
A. What do we mean when we say we perform work?

B. Why are levers useful?

C. What are forces?

PART II - FILL-INS 6 minutes

Below is an illustration of a 12 foot lever which can help an ordinary man to lift a 600 pound load.



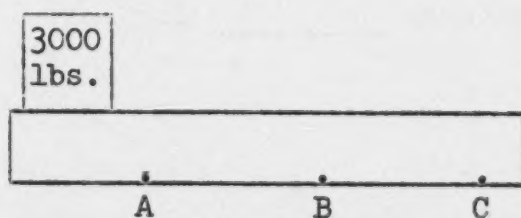
Here are some questions about this lever. Fill in the blanks below with the correct answers.

1. The downward push at "c" is called the _____ force.
2. The part of the lever labeled "b" is called the _____.
3. To lift the 600 pound load at "a" requires a lifting _____ at "a" of _____ pounds.
4. A downward push of only _____ pounds is needed at "c" to lift the 600 pounds at the other end.
5. The force at "c" is _____ than the force at "a".
6. The lever has to _____ the size of the force applied at "c" in order for it to be able to lift the 600 pound load at the other end.
7. The force at the "c" end of the lever is _____ to the lifting end.
8. A downward force has been used at the "c" end of the lever and the load at "a" has been lifted. This means that the _____ of the force has been changed.
9. In order for the lever in the diagram to work properly we must not be able to bend it. Therefore the lever must be r _____.
10. If a man pushes the lever down three feet at the "c" end of the lever, the load at the other end will rise _____ feet.

PART III - MULTIPLE CHOICE ITEMS 6 minutes

Instructions: Pick out what you think is the best answer and put a check mark ✓ alongside it.

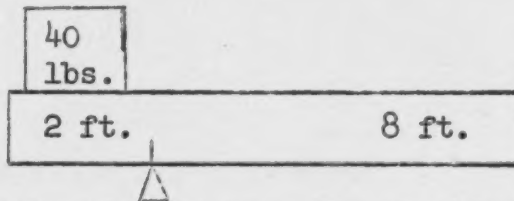
1. If a man lifts a 15 pound bag of cement off the ground, how much work has he performed?
- ☐ a. 15 foot-pounds of work
☐ b. no work
☐ c. depends on how much force he used
☐ d. depends on how high he lifts the bag
☐ e. depends on how strong he is
2. When a crane lifts a 2,000 pound automobile, how big a lifting force must the crane have?
- ☐ a. less than 2,000 pounds
☐ b. more than 2,000 pounds
☐ c. exactly 2,000 pounds
☐ d. depends on how high the automobile is lifted
☐ e. none of the above
3. To move or lift any object always requires a
- ☐ a. lever.
☐ b. force.
☐ c. machine.
☐ d. fulcrum.
☐ e. all of the above.
4. When a load is lifted off the ground with a lever, the amount of work performed is equal to the amount of force times the
- ☐ a. weight of the load.
☐ b. distance the load is lifted.
☐ c. length of the entire lever.
☐ d. direction of the force.
☐ e. all of the above.
5. The fulcrum may be placed at one of three places: A, B, C in the diagram below.



Where should the fulcrum be placed so that the 3,000 pound load can be lifted with the smallest downward push at the other end of the lever?

- ☐ a. A
☐ b. B
☐ c. C

6.



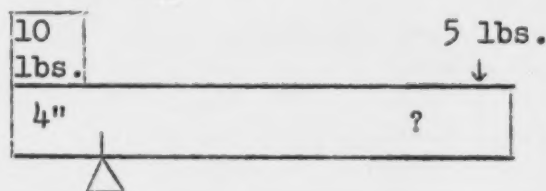
How much of a downward push do we need to raise the 40 pound load?

- ☐ a. 2 pounds
- ☐ b. 8 pounds
- ☐ c. 10 pounds
- ☐ d. 20 pounds
- ☐ e. 40 pounds

7. In the diagram above if the push down covers four feet the load will be raised _____ feet.

- ☐ a. 1
- ☐ b. 2
- ☐ c. 4
- ☐ d. 8
- ☐ e. 10

8. In the diagram below, what length do we need from the fulcrum to the applied force of five pounds in order to lift the load of 10 pounds?



- ☐ a. 5 inches
- ☐ b. 8 inches
- ☐ c. 10 inches
- ☐ d. 12 inches
- ☐ e. none of the above

9. Objects that are moved by pushes or pulls move

- ☐ a. in the direction of the applied force.
- ☐ b. in the direction of the lifting force.
- ☐ c. in a direction opposite to the applied force.
- ☐ d. in a direction opposite to the lifting force.
- ☐ e. none of the above.

10. To say that 12 foot pounds of work has been performed means that

- ☐ a. a 12 pound load was lifted one foot.
- ☐ b. a 6 pound load was lifted two feet.
- ☐ c. a 4 pound load was lifted three feet.
- ☐ d. a 2 pound load was lifted six feet.
- ☐ e. all of the above are correct.

LEVERS

ACHIEVEMENT TEST

Immediate and Delayed
Post-Test

WQED

Junior High School Science

Name _____

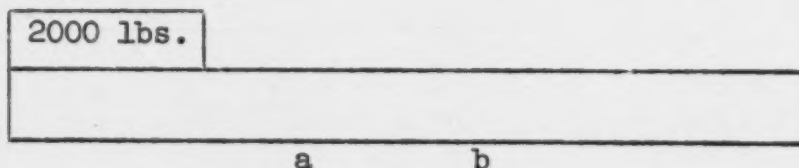
Grade _____
7th or 8th

School _____

PART I: 6 minutes

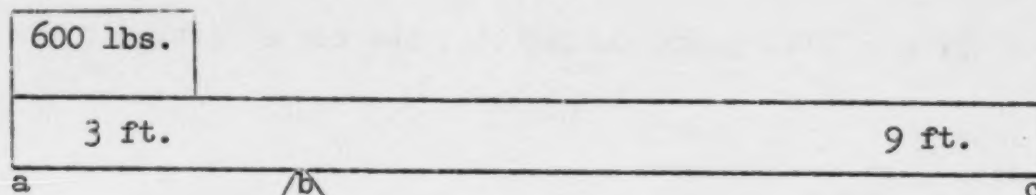
Instructions: Answer the following questions in your own words.

1. Why is it possible to use a force which is less than the weight of a load when we use a lever to lift that load?
2. What do we mean when we say we perform work?
3. In the diagram below, what advantage would there be in putting the fulcrum at "a" rather than at "b"?



PART II - FILL-INS 5 minutes

Below is an illustration of a 12 foot lever which can help an ordinary man to lift a 600 pound load.



Here are some questions about this lever. Fill in the blanks below with the correct answers.

1. The downward push at "c" is called the _____ force.
2. To lift the 600 pound load at "a" requires a lifting _____ at "a" of _____ pounds.
3. A downward push of only _____ pounds is needed at "c" to lift the 600 pounds at the other end.
4. The lever has to _____ the size of the force applied at "c" in order for it to be able to lift the 600 pound load at the other end.
5. The force at the "c" end of the lever is _____ to the lifting end.
6. A downward force has been used at the "c" end of the lever and the load at "a" has been lifted. This means that the _____ of the force has been changed.
7. In order for the lever in the diagram to work properly, we must not be able to bend it. Therefore, the lever must be _____.
8. If a man pushes the lever down three feet at the "c" end of the lever, the load at the other end will rise _____ feet.
9. When an object is moved by a push or pull, it moves in the _____ of the push or pull.
10. A push or pull is called a (an) _____.
11. Levers are used to increase _____.
12. To move or lift any object always requires a (an) _____.

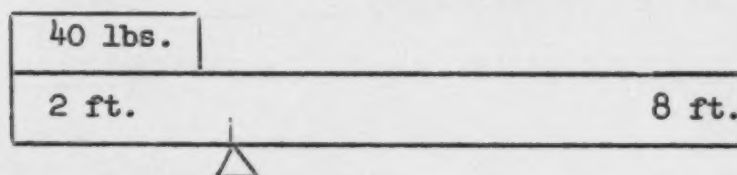
PART III - MULTIPLE CHOICE ITEMS 5 minutes

Instructions: Pick out what you think is the best answer and put a check mark ✓ alongside it.

1. When a crane lifts a 2,000 pound automobile, how big a lifting force must the crane have?

- ☐ a. less than 2,000 pounds
- ☐ b. more than 2,000 pounds
- ☐ c. exactly 2,000 pounds
- ☐ d. depends on how high the automobile is lifted
- ☐ e. none of the above

2. How much of a downward push do we need to raise the 40 pound load?

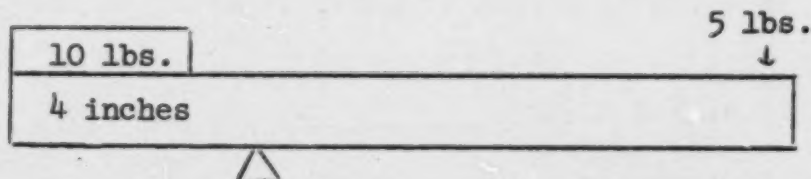


- ☐ a. 2 pounds
- ☐ b. 8 pounds
- ☐ c. 10 pounds
- ☐ d. 20 pounds
- ☐ e. 40 pounds

3. In the diagram above, if the push down covers four feet the load will be raised _____ feet.

- ☐ a. 1
- ☐ b. 2
- ☐ c. 4
- ☐ d. 8
- ☐ e. 10

4. In the diagram below, what length do we need from the fulcrum to the applied force of five pounds in order to lift the load of 10 pounds?

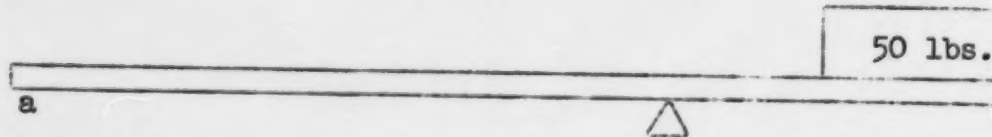


- ☐ a. 5 inches
- ☐ b. 8 inches
- ☐ c. 10 inches
- ☐ d. 12 inches
- ☐ e. none of the above

5. To say that 12 foot pounds of work has been performed means that

- ☐ a. a 12 pound load was lifted 1 foot.
- ☐ b. a 6 pound load was lifted 2 feet.
- ☐ c. a 4 pound load was lifted 3 feet.
- ☐ d. a 2 pound load was lifted 6 feet.
- ☐ e. all of the above are correct.

6.



The applied force at "a"

- ☐ a. is greater than 50 pounds.
 - ☐ b. is equal to 50 pounds.
 - ☐ c. has no relation to the 50 pound load.
 - ☐ d. depends on how high the load is lifted.
 - ☐ e. none of the above.
7. When a load is lifted by a lever, the work done equals the
- ☐ a. applied force times the distance it moves.
 - ☐ b. lifting force times its distance from the fulcrum.
 - ☐ c. applied force times its distance from the fulcrum.
 - ☐ d. lifting force times its distance from the applied force.
 - ☐ e. none of the above.
8. In a lever, the applied force times its distance from the fulcrum must equal the load times
- ☐ a. the applied force.
 - ☐ b. its distance from the applied force.
 - ☐ c. its distance from the lifting force.
 - ☐ d. its distance from the fulcrum.
 - ☐ e. the distance from the applied force to the fulcrum.

